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GEOLOGY · MINERALOGY · PALAEONTOLOGY · MAMMALOGY · ORNITHOLOGY

INVERTEBRATE ZOOLOGY · ANTHROPOLOGY · PHYSIOLOGY · EDUCATION

ENTOMOLOGY · ICHTHYOLOGY · HERPETOLOGY

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The American Museum of Natural History

CONTENTS OF VOLUME XX

JANUARY–FEBRUARY

MARCH–APRIL

MAY–JUNE

SEPTEMBER–OCTOBER

NOVEMBER–DECEMBER

ILLUSTRATIONS

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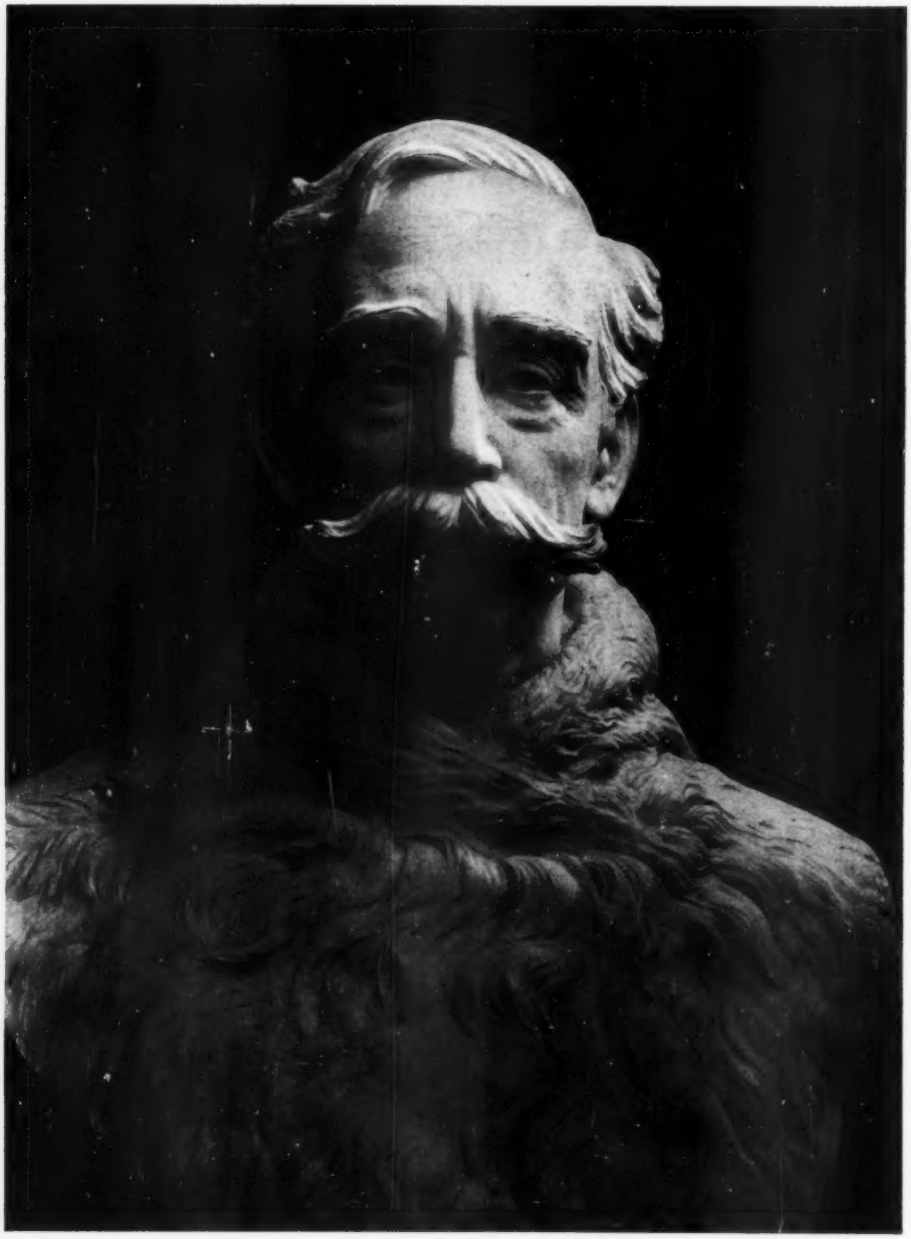


PEARY, 1856-1920

Portrait from the bust executed in Carrara marble at Florence by the American sculptor, Couper, and installed in one of the niches in Memorial Hall, American Museum of Natural History, in 1913

The American explorer, Admiral Robert E. Peary, U.S.N. (retired), reached 90° N. latitude on the sea ice, and indicated with an unfurled American flag the location of the North Pole, April 6, 1909, just eleven years ago. His success came after twenty-three years of Polar work, built on a foundation of the successes and failures of more than three centuries of effort by men of different nations

NATURAL HISTORY

VOLUME XX JANUARY-FEBRUARY, 1920 NUMBER 1

Peary

By HERBERT L. BRIDGMAN

PEARY'S life was an epic in two parts; the first of preparation, the second of performance. When the tale is fully told, as it should be in the fullness of time, the world, which has made him one of its foremost and familiar figures, will learn that his was no sudden or erratic ascent like a rocket in the midnight, but a steady upward advance, that unbroken spiral with constant gradient and constant approach to its culmination.

Washington had reached the meridian before he assumed command of the Continental Armies, but his field work among the Alleghenies and in the Ohio Valley beyond, his civil training among the landholders and patricians of the Old Dominion, had given him vision of the future, of the extent and resources of his country, and of the government and institutions necessary for their development. Lincoln had passed his semicentennial before he assumed the great office in which he was to meet death and immortality, bringing to his cares and duties more than a quarter of a century's unbroken and intimate practice among the courts and the politicians of Illinois. And Peary was quite beyond the first flush of young manhood when at thirty he essayed his first adventure from the sheltered Godhavn upon the hitherto untrodden, mysterious ice cap, foretelling that quest which was to occupy and crown the remainder of his active life, projected against a background which had in it every demand of physical and mental endowment, long and arduous training, so that when in 1891, five years later, this daring young lieutenant of the Navy essayed to take up again the challenge of the implacable North, the human composite was complete and effective. "Poets," runs the old adage, "are born, not made." Explorers like Peary are both born and made, or rather, they make themselves by preparation of mind and body which spares nothing, forgets nothing.

Maybe I can set forth Peary more clearly, as certainly more easily, by a few word pictures from the gallery of memory which show the mood and manner of the man, because of their absolute freedom from accessories or from influences of any incident or environment. Of all the things that Peary was not he was never a *poseur*, or possessor of the least trace of affectation. So that all these incidents, like so many others which come thronging to the mind unbidden, are simply the unstudied, living expression of the real man—and there could be no other whether among all the comforts of home and the company of family and friends, or solitary and alone, with only his faithful "huskies," facing all that an Arctic winter might mean, while the ship with all dearest to him was receding from his sight. Perfectly at ease and with every muscle and thought fully controlled, Peary in great trial or in keenest triumph never

Faithfully yours
Harry S. Truman

made a scene. He was always master of himself and the situation.

Well do I remember my first sight of the explorer, returned with acclaim, to which the public, still recalling the melancholy scenes of Cape Sabine, only languidly responded. It was on a rainy autumn evening in a rather dingy and dimly lighted, sparsely filled Brooklyn hall, and he was trying to tell his audience something of what he had seen and done; of his winter in a real house at Red Cliff on McCormick Bay, and of his great thousand-mile traverse of the Greenland ice cap, both radical departures as to method and objective from former Arctic field work, a complete reversal and contradiction of everything which had gone before. The usual perversity of inanimate things possessed the lantern slides so that they utterly failed to appear, yet the lecture, "the voice and nothing more," was all that was necessary to demonstrate that a new era in Arctic exploration had arrived, and that this young officer was only telling the first chapter of what might ultimately be the world's greatest story. Who knew to what latitude Greenland might not reach, and now that the "great ice" had been conquered, why might not the trail lead to the Pole itself?

Later, a few weeks, came another and "capacity" Brooklyn audience, and the graphic and illuminating slides were there; then the great Academy was twice crowded to the doors, and children now grown will never forget the day they saw on the stage the ever faithful "Mat" clad in skins, the dogs and sledges and the igloo lights glimmering through the white expanse, as effective a bit of Arctic realism as ever staged. Then began that country-wide tour, to crowded audiences everywhere, which financed the 1893–95 expedition; and through it all, with scientific honors and social attentions, Peary was always the same—concentrated, imperturbable, intent on getting away for the North at the earliest day the next summer.

Six years later he was again ready to leave for the North and another assault on the forces which had baffled him so long. The "Windward," Lord Northcliffe's gift, had left New York a day or two before and for Sydney, where he was to join her, and as he, straw-hatted, in a summer suit, swung on a Broadway uptown car for the Grand Central, with his cheery, "Good luck! Take care of yourself," one would never have believed that was the proper way to say farewell, when it might be the Pole or it might be forever. But that was Peary's way. It was all in the day's work, and it seemed "so like every day" both to him and to Bartlett, even within sight of the goal.

Then came that Fourth of July

Photograph by Peary

Camp on the shore of Allman Bay in which the "Windward" wintered, 1898–99. The flag followed him in his travels for fifteen years and finally waved above the sea ice at the Pole.

The portrait on the page opposite, from an autographed picture which Peary gave to the writer at Eagle Island in 1911, shows the explorer just after he had been given the thanks of Congress (by special act of March 3, 1911) and promoted to the rank of rear admiral in the United States Navy. Peary as an explorer was both born and made, or rather, he made himself by preparation of mind and body, sparing nothing, forgetting nothing

Roosevelt turned and, placing his hand in Peary's, said, "I believe in you, Peary, and I believe in your success." We who were present cherished the auspicious prophecy, and counted it a good omen that it occurred on the deck of the ice-fighter named for the President of the United States

farewell at Oyster Bay when the President of the United States boarded the stanch American ice-fighter bearing his name, accompanied by that gallant son who was later to give his life for his country, "over there." The two men, Peary and Roosevelt, contrasts in some respects, duplicates in others, appreciative and sympathetic, each enjoyed the situation to the full; Peary, that he had the opportunity to put before the President's eyes the men, the ship, and the equipment which meant so much to him and to his country; and Roosevelt, eager as a boy and with his enthusiasm for adventure and discovery aflame, allowed nothing to escape his inquiry and comment. As, after inspection of everything above and below, and, going over the side, he turned and, placing his hand in Peary's, said, "I believe in you, Peary, and I believe in your success," we all counted it a good omen, and cherished his auspicious prophecy.

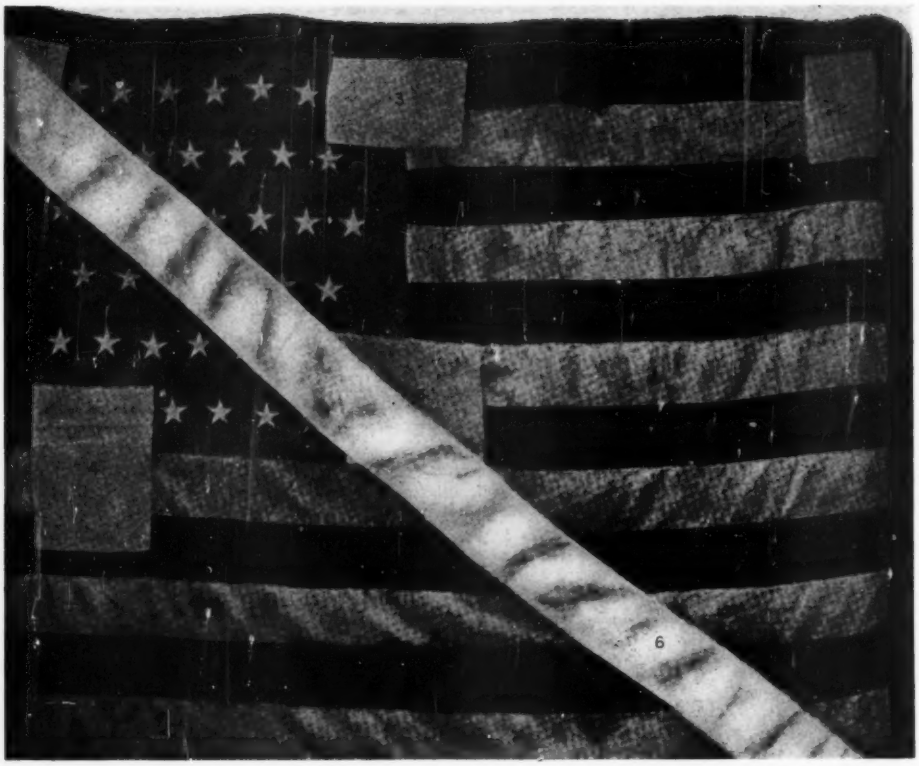
The great naval parade up the Hudson in October, 1909, a feature of the Tercentennial Celebration, was a bitter, trying day for Peary, but one which showed—what all his friends knew—of what stuff he was made. Some timid souls had even gone so far as to urge him to decline the committee's invitation to place the "Roosevelt," bearing the North Pole flag, at the head of the column, but having accepted, nothing could deter or swerve him, and although the faster steamers outfooted her, she kept her place and made the complete journey with colors flying. Occasionally a taunt or challenge would come over from some insulting, impertinent crowd of excursionists, but Peary would not suffer a word in answer. "It does them more harm than it does us," he said calmly, as he stood in full view on the quarter-deck.

Peary was ever himself, the same in the North or at home, meeting or part-

ing. He met you with a smile and said good-bye with the lighted eye which means "We shall meet again." When he went over the side of the "Falcon" that August morning in 1894, leaving wife and year-old daughter homeward bound in the cabin below, every hand was cordially grasped with a cheery good-bye, and the stalwart huskies bending to the oars, we soon saw him a mile away, erect in the stern of the boat, her white sail drawing full and signaling to us, "Good luck and safe voyage." If any one thought of a winter of torture and a year of privation, it was certainly not the commander, who remained to face them while all the rest of his party, but one, retreated to home and safety. When the "Diana" rounded Sunrise Point, that steep, rocky promontory which thrusts itself into the sheltered, land-locked harbor of Etah, one bright August morning in 1899, her company saw an erect, blue-clad figure holding an improvised staff from which floated straight out into the glittering sunlight the Stars and Stripes, and none needed glasses, or to be told twice, that Peary and the flag were still there. And when, two years after, the "Erik," in summer snow storms pushed her way through the same waters to the anchorage of the "Wind-

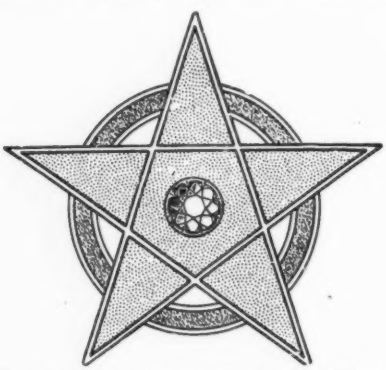
Courtesy of Brown Brothers

Peary was ever himself, the same in the North or at home, meeting or parting. He met you with a smile and said good-bye with the lighted eye which means "We shall meet again"



The silk flag Peary carried on the expedition that reached the North Pole.—He cached pieces cut from it at various places in the Far North: Numbers 1 and 2 at Cape Morris Jesup, 3 at Cape Thomas Hubbard, 4 at Cape Columbia, 5 at Peary's "Farthest North," 87° 6′, and 6, on the ice at the Pole

ward," which had taken Mrs. Peary and little Miss Peary north more than a year before, we made out the flag of our country flying, even before we could see a sign of life on the ship.



The medal of honor presented to the discoverer of the North Pole by the Peary Arctic Club on the third anniversary of that great event bore the inscription of five of Peary's achievements: "The Crossing of Greenland, 1892"; "Securing the Great Meteorites, 1897"; "Insularity of Greenland, 1900"; "Farthest North, 1906"; "North Pole, 1909"

Duty, honor, country—these made Peary's living motto. Science and patriotism fed the flame of his ambition, and on that eventful day in 1909 when he reached the Pole, it was the flag of America which proclaimed the victory

A month later, when, after cruising among all the Eskimo settlements and gathering equipment for the next spring's attack on the Pole, we had been obliged to desist from an attempt to land Peary and his party at Cape Sabine and to put them ashore in an improvised camp on Herschel Bay, he accompanied the last parting grasp of the hand as the ship's propeller turned, with "Keep your flags up. We'll keep our glasses on you, and when we can see you no longer we shall know that you are safely on your way home."

Maybe these pastels from memory's crowded gallery, although but thumbnail sketches as it were, will give a clearer and better idea of the real

Peary than more detailed descriptions or refined analysis. Of his personality none could be near and not be conscious. Grave, calm, and perfectly self-contained, yet as far as possible from chilling reserve or bored indifference, with a sense of real humor, which, among intimates, could take and make a joke with the best—yet always with a fine and inborn sense of the courtesies and conventions, of the rights of others, and the value of time.

Peary rarely in my hearing talked much about himself, his use of the first person singular was sparing to the last degree, and if he discussed the campaign, either past or future, it was always in reference to the immediate business in hand, some matter of detail and mutual coöperation, in which each should bear a hand and know and understand the work which had been cut out for him. Even when the great prize had been won, and the victory of twenty years achieved, his manner, tempered by repeated repulse and disappointment, did not outwardly change, and no man ever heard from him a boasting or vainglorious word.

To define the value and estimate the effect of Peary's work is not the present purpose. Nor is it necessary. The scientific societies and authorities of the world without exception or reservation have done that, and probably no other man living or dead has received more emphatic and unanimous recognition and reward of merit. It is proper, however, here to say that no association, nor appreciation of his effort and endurance gave him more gratification or kindled livelier response than that from the American Museum. President Jesup's support and counsel were strength and inspiration, and the confidence and friendship of the officials and staff were a source of unfailing satisfaction.

"Duty, honor, country," the West Point cadets read on the great oriel of their noble chapel, and, unwritten, these were Peary's living motto. Ambition urged him on, but science and patriotism fed its flame, and on that eventful April day when he reached the Pole, it was the flag of his country, with him in all his Arctic wanderings, to be above him at the grave, that proclaimed the victory. Reviewing the causes and recalling the man, both seem simple and harmonious.

Blood of France and Britain mingled in Peary; the waters and islands of Casco Bay and the hills around trained the athlete, the sailor, and the hunter; the schools and college of his state gave him knowledge of books and men. Florida and Nicaragua gave him the practical and severe discipline in his profession, so that when he took the field, actually entered the arena for his life work, there was no joint in his armor, no detail of mental or physical equipment deficient. To complete the picture, to inspire and illuminate the life, to all this may be added ideal filial, conjugal, and paternal relationships, to which more of success than the world will ever know is due.

Echoes of "taps" and the volleys followed us out of snow-clad Arlington. Of whom could it more worthily be written in the immortal lyric inscribed on the roadside tablet:

> "On Fame's eternal camping ground
> Their silent tents are spread,
> And glory guards with solemn round
> The bivouac of the dead."

Courtesy of the New York Times

THE CAISSON WITH A NAVAL ESCORT WOUND ITS WAY THROUGH THE LANES OF ARLINGTON CEMETERY

ADMIRAL ROBERT EDWIN PEARY, 1856-1920
NORTH POLE, 6 APRIL, 1909

Medal by Sigurd Neandross

The scientific societies and authorities of the world without exception or reservation have defined the high and authentic value of Peary's work, and probably no man has ever received more emphatic and unanimous recognition and reward of merit. In witness thereof more than a score of medals have been presented to him by the great geographical and exploring societies of Europe and America

Scientific Research as a Public Function

By T. D. A. COCKERELL

Professor of Zoölogy, University of Colorado

IT is a commonplace observation that most of our material progress is due to science. The English naturalist, Wallace, thought that there had been more discovery and invention during the nineteenth century than during all previous centuries. It is certainly true that the whole structure of civilization has been altered as the result of scientific work, and today the rate of development is greater than ever before. Progress begets progress, and we are perpetually obliged to readjust ourselves to new conditions. Whether we approve or object, we have no option if we wish to maintain our place in the world. We are somewhat in the position of the Red Queen in *Through the Looking-Glass,* who had to run as fast as she could to keep in the same place.

During the early part of the nineteenth century, Malthus attracted much attention by his dismal prophecy of the overcrowding of the world and the prospective lack of the necessities of life. Populations have greatly increased since his time, but science has so greatly augmented man's power to produce wealth, that we have more per capita than in any previous period. Not only this, but we can see ahead to a time when present production will look relatively insignificant. In modern times disease has been partly conquered, and premature death has been largely prevented. Here again it is a reasonable expectation that some of the most serious diseases will disappear within the lifetime of the youngest persons among us.

Along with this progress of science, and partly because of it, democracy has grown apace. The United States has demonstrated to the world that a whole continent can be organized successfully into a coöperative commonwealth. Kings, courts, and nobles have been discovered to be superfluous, and universal public education has proved itself a brilliant success. If we still fight, it is to combat the methods of a bygone age, and within the democratic fold war appears to have been abolished.

The gains of science and democracy have been enormous. Nevertheless, we are discontented and unsettled, deeply disappointed with the results of so much intelligent labor. We even look with a kind of envy at the naked savage, living a simple life in the primitive forest. He at least knows how to behave, and has little to regret. This is not mere meaningless sentiment, it is actually a fact that the average man is less accurately adjusted to his environment than most wild animals. We have created an enormously complex machinery which we do not know how to operate quite successfully.

It has often been said that the remedy for the ills of democracy is more democracy. So also, the remedy for the ills of science is more science. In other words, the scheme of things must be completed, the parts of the machine must be brought to a common level of efficiency. When we look out upon the present world, it appears that material advance has gone far beyond moral progress, and one is apt to wonder whether the former should halt to allow the latter to catch up. Professor Ross has shown how progress itself is a cause of delinquency, how all the crooks disport themselves in the margin of opportunity which fringes

the moving front. But the problem after all is very much like that which confronted our Army in the recent war. It was necessary to advance, but the gains had to be consolidated. The whole organization had to move together, according to a definite plan, or the very successes would have turned into defeats. It requires little investigation to determine that the front line of our American civilization is extremely irregular, and that many of the trenches are poorly constructed. We are doing things in a far finer and grander way than the savage, but not doing them so well.

The problem of science is the problem of democracy; it is even at the root of morality. What morality is there, in this world, but to learn where we are, and where we are going, and act accordingly? Good morals must be judged by their results, and not by the intentions of those who practise them. The world resounds with the conflicts between well-meaning persons who might have peace and harmony if they would only stop to use their intellects. Take a concrete instance, that of the recent controversy in the steel industry. It apparently never occurred to the leading operators to ascertain the precise effect of their rulings upon the thousands of persons working for them. Neither did it apparently occur to the strikers to secure expert testimony, and present to the public a statement of the inescapable objective facts. A skilled physiologist could show the effect of a twelve-hour day, under the conditions of the steel industry, in a manner that could not be gainsaid. A sociologist could elucidate other matters, and even a psychologist might have his contribution to make. Well, operators and public, if it is demonstrated beyond contention that the industry is impairing the efficiency and spoiling the lives of thousands of persons, do you wish that to continue? Of course you don't; but as things are, you really don't know much about it, and give yourselves the benefit of the doubt. The truth is, you are not competent members of a democracy, and so the democracy you belong to is a lame affair, and not at all what it ought to be. But you are mostly honest and well-meaning, as were the medieval monks who carried the holy relics around the churchyard in an effort to combat the bubonic plague. They should have killed the rats.

We are apt to think of scientific research as something above the clouds, something which requires a genius for its production. Darwin, Newton, Kelvin, or Pasteur,—can such men be made to order or fitted into a public organization? When we think of the great theories, the great discoveries, they seem like gifts of the gods, bestowed by the caprice of heaven on a public which has done little to deserve them. The actual facts, however, are quite different. All these men did an immense amount of scientific work and utilized the work of many others. It was from the synthesis of patiently acquired data that the discoveries or generalizations emerged. All these men, moreover, required material accessories, and had them. They also required, and had, the coöperation of their fellows. A nation is justly proud of its great scientific men, because they represent the finest flowers of national activity. The same principle holds good in the arts, even in a subject so little constrained as poetry. Lady Gregory, lecturing in this country on the Irish drama, urged us to develop local dramatic talent everywhere. This, she said, partly because it is worth while in itself, and partly because it is only in an environment of interest and opportunity that great drama is likely to arise. Grant that we cannot make poets to order, we can at least prepare the ground in which the seeds of poetry will grow. Precisely the same is true of science.

For the practical purposes of democracy, however, we need the minutiæ of research. We do not expect to run the city or factory by the light of some astounding new principle presently to be discovered. Instead of that, we want to know about the distribution of mosquitoes, the character of the fatigue curve, the condition of the milk, and so forth. We not only want to know these things, but we need up-to-date information all the time; the price of well-being is eternal vigilance. We cannot wait until some gifted individual feels moved to investigate; we must organize a scientific staff. Some people would deny the name research to such activities, just as they deny the title poetry to many kinds of verse. We need not quarrel about the name, but it is actually impossible to draw any distinct line between the different types of work. The most simple details, if gathered systematically and according to a plan, may be made the basis of important generalizations. This is true even of such a thing as the census, in the making of which the research spirit is wholly absent. We need to see ourselves—not indeed as others see us—but as we actually are. We must constantly measure our powers and opportunities, and plan our conduct in the light of what we have learned. This we do not do, and yet it is easy to see that we might vastly improve our condition, and do away with the leading causes of discontent.

At the time of the Walsh Industrial Commission, I tried to interest the then president of the University of Colorado in a plan for the continuous study of the local industries, particularly coal mining. Up to the present time it has not been possible to organize such a bureau as I contemplated, and in fact the University has no research program. While teaching has been fully systematized, so that every grade earned by every student is duly recorded, research is a voluntary or, as it were, parasitic industry. We are by no means peculiar in this. The university is the natural and proper center for research. There are to be found the laboratories and libraries, and there should be the men. The complaint is made that the public will not support the work, it will not even adequately support the teaching. But the public has never had the matter presented to it in any intelligible form. It is necessary to make some exhibit of the goods for sale in order to obtain a purchaser. The people have paid over and over again for they knew not what. It is a sign of intelligence on their part if they want to be shown, but it should be easy to show them.

It must be admitted that our scientific men are not yet wholly awake to their great duties and responsibilities. They are still imperfectly socialized. They justly dread the interference of ignorant or stupid persons in authority, and to avoid this danger would preserve their independence to the uttermost. Science undisciplined and unorganized is at any rate free. Yet the work of the world must be done, and whether it is done wisely or stupidly must depend upon science. We must therefore strenuously object to the minute passed by the Council of the American Association for the Advancement of Science, requesting the sections to exclude papers dealing with current political questions, on which public opinion is divided. Partisan propaganda posing as science would be detestable, but it is precisely upon those questions on which opinion is divided, that the clear light of science should be shed. When we are sufficiently educated, we shall habitually turn to science as to an umpire.

There is one great contribution to the public good which I think should be made without delay. The ablest experts in the country should get together and define the *American stand-*

ard of living. Not the actual standard, determined by statistics, but the optimum standard possible in an enlightened democracy.[1] What does a man need to maintain his health and working efficiency? The inquiry would naturally resolve itself into two parts. One would deal with personal requirements, such as food, clothing, housing, and so forth. The other would have to do with social arrangements,—education, parks, opportunities for recreation, and the like. The standard could not be exact; but if carefully defined and supported by adequate authority, it could be given sufficient publicity to have it discussed in nearly every home in America. It would serve as a measuring stick to measure roughly and compare the conditions in every industry or occupation. It might be revised from time to time; and as fast as the facts could be gathered, special standards should be indicated for special circumstances. While the obvious and immediate purpose of the standard would be to raise those *below* it, there might be some utility in considering cases *above* it, as indicating wasteful and purposeless expenditure. The discussion of the standard would also call attention to the problem of adequate production. Some economists think there would not be enough to go around, but it is inconceivable that with modern methods we could not meet every reasonable requirement.

During the recent war, we feared that it might be difficult or impossible to carry on all the important agricultural operations, and in Colorado we discussed the possibility of dismissing the university students for a few weeks to prepare the ground or get in the crops. No such step proved necessary, and there is no doubt that such instruments as the tractor and the silo (to mention the two most conspicuous to the passer-by) had a great deal to do with the successful conduct of the war. Still more striking are the triumphs of plant breeding, and one who has followed all these matters with any degree of attention cannot fail to be optimistic regarding the possibilities for enormously increased production. Sir Daniel Morris recently made the following statements, as quoted in *Nature*, September 11, 1919, page 37:

"As the result of Biffen's plant-breeding work at Cambridge, new wheats have been produced and grown over extensive areas in the eastern counties [of England] that have yielded crops at the rate of 50 to 60 bushels per acre. In one instance an area of a little over twenty-seven acres has yielded 2072 bushels, or an average of 77 bushels per acre. This is to be compared with the average yield of wheat in this country at about 32 bushels per acre. The new wheats are not only more productive, but are less liable to disease, and the quality of the flour is superior to that of ordinary English wheats. In regard to India it is estimated that the Pusa wheats raised by the Howards will shortly be established over five million acres, and it is anticipated that they will bring in an increase in the value of the agricultural produce of India, in one crop only, of 75 lakhs of rupees of five millions sterling."

[1] A good beginning has been made in a recent bulletin: "Tentative Quantity and Cost Budget Necessary to Maintain a Family of Five in Washington, D. C., at a Level of Health and Decency." *Bulletin of the United States Department of Labor*, 1919.

A Miocene Catastrophe

By DAVID STARR JORDAN

Chancellor Emeritus, Leland Stanford Junior University

A GREAT many years ago, in round numbers let us say about 2,000,000 B.C.. in the age called Miocene, the coast line of California was in a formative stage. Great deposits of sand and clay were being rolled up and folded as mountain chains, and their nascent peaks and ridges formed an archipelago of islands with sheltered bays. Here were developed immense masses of diatoms, microscopic plants, each with a fine shell of silica, most of them having the form of a flat disk, adorned with thimble-like depressions and spinules of complicated sorts. The number of these creatures must be beyond conception for, in the locality mentioned below, they are piled up solidly to the average depth of fourteen hundred feet over a territory two and one-half miles long, and more than a mile and a half in breadth.

In this locality the deposits are free from sand, which shows that no fresh water came in; but in other places, over dozens or hundreds of miles, from Kern County to Orange, the diatom masses are interspersed with sand and clay and at times completely buried under them. From above these buried masses exudes the oil called petroleum. It is known that each diatom when alive secretes a minute droplet of this oil. But this is a theory; now to a concrete fact.

In a little bay on the north side of the Sierra Santa Ynez in Santa Barbara County, just above the present town of Lompoc were measureless masses of diatoms, covering the bottom at first to a depth of about 950 feet. For some reason this bay was chosen as the spawning ground for a herring of those days, known now by the name of *Xyne grex*.[1] This fish was much like a modern herring, except that its surface bones were covered with enamel, a ganoid fashion of those Miocene years long since gone out of date, so far as herrings are concerned. This species had, moreover, a row of sharp enameled spines along the edge of its belly. Something like this still persists in many forms of herring—as the menhaden and other so-called "sawbellies," but these are plain nowadays, the enamel all off.

Into the bay at one time came millions on millions of these herring—all of a size—six to eight inches long, doubtless for spawning purposes. But they covered the whole bottom of the bay—four square miles—and very evenly at that. That is the marvel, and now comes the catastrophe. For none ever got away; they all lay down and died and were promptly buried under the diatoms—350 feet of diatoms at least. But the erosion of the years has cut into these masses in different places, laying bare the strata in which the *Xyne* lie. And whenever one strikes that horizon, there are the fish, all in the same stratum, none below, nor for many feet above. The skeletons are all well preserved, not much crowded, and the organic part of the skeleton is carbonized so that the bones are all dark brown or black.

The accompanying photograph (on page 20) shows a slab of diatom rock, twenty inches by sixteen, with thirteen of these fishes upon it, besides parts of others. This seems to be a fair average for the whole stratum, and indicates that the total number in the bay on the day of the holocaust was about 1,337,195,600, a mighty school of fish!

About six feet above this deposit of *Xyne*, throughout the basin, there lies a thin layer of transparent volcanic

[1] *Fossil Fishes of Southern California.* By David Starr Jordan and James Zaccheus Gilbert, 1919, pp. 25–26.

GREAT DEPTHS OF THE DIATOM DEPOSITS AT LOMPOC, CALIFORNIA

This picture of a quarry among the diatom hills of California indicates to the imagination better than figures the countless myriads of the microscopic plants which were deposited in this place. The number has been calculated as represented by the numeral 1 with thirty ciphers attached. But for all we know, forty ciphers may be equally correct. These diatoms, chiefly species of the genus *Coscinodiscus*, were developed in the locality where they are now found when this was a sheltered bay among an archipelago of islands, formed by the nascent peaks of the California coast. Among other peculiarities of the deposits is their exudation of petroleum, a phenomenon as yet not wholly explained, although probably connected with the fact that each diatom when alive contains a minute droplet of oil

A RECORD IN STONE OF AN EXTINCT HERRING

Earthquake or other catastrophe destroyed more than a billion herring—they themselves wrote the story in stone for future ages to read. In what was once a bay, when the Sierra Santa Ynez, of Santa Barbara County, California, were below sea level, are to be found the remains, representing an extinct species, *Xyne grex*. These myriads of fish had entered the bay and spread over the four square miles of bottom, doubtless for the purpose of spawning, when some catastrophe overtook them and they all, with one accord, lay down and died. Subsequently their remains were buried under masses of diatoms. The organic parts of the skeletons are carbonized so that the bones are black, as is generally the case with animals decomposed under water where more hydrogen and oxygen than carbon are given off with a residue of the last, the final result being the noncrystalline mineral, collophane (carbono-phosphate of lime)

Masses of diatoms have been heaped up in this small pocket of the Sierra Santa Ynez, in some places to an average depth of fourteen hundred feet. Diatoms are microscopic plants (a few common species shown on page 84), each encased in silica. Countless millions of these microscopically small cases of silica, mixed with clay and sand, are found in deposits in many localities including the greatest depths of the sea and the rocks of high mountain ranges. The California deposits are, perhaps, the most notable in the world in extent and thickness, and above these diatom masses are patches of coarse conglomerate containing many bones of whales and sharks' teeth

Diatomaceous earth is employed for many purposes, depending somewhat on its texture and the amount of clay and sand intermixed with the siliceous cases. The deposits at Lampoc, California, are quarried for a material used as nonconducting packing for steam pipes and for filtering liquids. It was in a section of this deposit, about 350 feet below the present surface, that the herring shown on the opposite page were entrapped in Miocene times. In the layers above occur numerous fossils, but there are no such masses of them as were accumulated by this single catastrophe

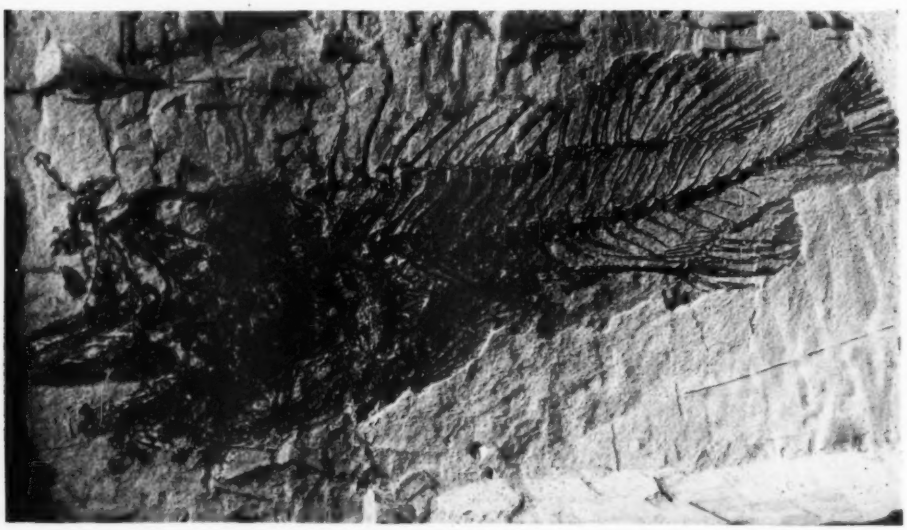
glass. Again, long after this was deposited, the whole area was thrown together into low folds. The *Xyne* deposits now stand at an angle of about thirty degrees in the place where this slab was obtained.

Above the *Xyne* lie further deposits of pure diatoms, to the depth of 350 feet. In the upper stretches are many fossil fishes, of about twenty kinds, so far as observed, largely broken into fragments. Four kinds of Spanish mackerel, two kinds of porgy, a big sea-bass, three species of flounder, two rock-cod, two kinds of croaker, and others are present. Among these are two species of herring, one of them being *Xyne*. This, however, nowhere except in the one great layer, exists in mass or in large numbers. All these fishes of the upper regions are mainly molds, imprints of a fish skeleton, replaced by diatoms. None of the herring skeletons is black or carbonized, like those taken in the great layer below. In the upper strata occur also a species of *Mergus* (fish duck), a heron, a porpoise, and a whale. Above the whole diatom mass lies in places a coarse angular conglomerate, with many inchoate bones, mostly of whales, teeth of a man-eater shark, and here and there masses of limestone filled with *Pecten* shells and other Miocene mollusks.

These hills are now occupied by quarries, the diatom masses being sold under the patented trade name of "Celite." The material is used as non-conducting packing for hot pipes ("Sil-o-Cel") and for filtering liquids ("Filter-cel"). The siliceous crusts of the diatoms are insoluble in ordinary liquids, and by pouring them into a fluid and then filtering, everything in suspension is caught by the diatoms.

Two problems remain, both probably insoluble. Why was this bay crowded with a billion individuals of *Xyne* to the exclusion of all other fish? Why did they all die instantly, quietly, with no sign of agony, and how were they hermetically sealed before going to pieces in decay?

Heat, poison gas, earthquake disturbance—you may answer. But no one knows, and anyone's guess is as good as yours or mine.



This big rock-cod (*Rixator porteousi*, shown less than one third size) probably perished in the same fashion as the herring but at a later date. Its head is crushed as is the case with fish which die in the sea, for the skeletons of the bodies are picked clean by small organisms, but the brain is left within the skull and causes these bones to decay

A Chapter of History and Natural History in Old New York

By GEORGE BIRD GRINNELL

THE wild life of New York City is for the most part transient; we see only birds of passage. During the migrations, native birds sometimes drop down into parks, back yards, or other open spaces, and are recognized by the passers-by as different from the English sparrow. People who know birds occasionally recognize thrushes, blackbirds, warblers, and even scarlet tanagers in the smaller parks; and sometimes other birds appear, as when a few years ago I saw a woodcock in Trinity Churchyard at Rector Street, and still longer ago, one in Union Square, which, when started, flew straight east through 16th Street to alight no doubt in Stuyvesant Square.

The larger parks, like Central Park and Bronx and Prospect parks, permit birds to live under more or less natural conditions, and shelter, besides the birds, a few mammals—two or three species of squirrels, cottontail rabbits, and other lesser creatures. A few years ago a brood of wild black ducks was reared each year in Central Park, and in the New York Zoölogical Park various wild ducks are bred.

The presence of many people whose minds are occupied with other things than wild life tends to make safe not a few wild birds that spend the summers and rear their young in safety close to the city throngs. In the tidewater flats and marshes of Long Island City and of the outskirts of Jersey City, there are still no doubt—as there were a few years since—many places where blackbirds, coots, rails, shore birds, and other species not often seen, breed each year in safety. Duck hawks still rear their young on ledges of the Palisades and it may well enough be that near New York there are other breeding places of large birds.

My boyhood was spent in the country on the banks of the Hudson in Audubon Park. This had been the home of John James Audubon, and was then six or seven miles from the built-up portion of New York City. The only way of reaching it was by train from the Hudson River Railroad Station at Chambers Street, or by a stage which twice a day plied between Saul's Tavern, at 162d Street and Bloomingdale Road, and the corner of 36th Street and Broadway. There were few buildings north of 35th Street, and market gardens, which supplied vegetables to the city, began on the west side of the town near 40th Street, and extended far into the country. Ground for Central Park had just been set aside, but nothing had been done to transform it from a great piece of wild waste land.

The conditions about Audubon Park were thus those of the country, and no doubt it was for this reason—because of its distance from the city and its freedom from people—that it had been chosen as a residence by the naturalist. In the woods and fields were found many of the birds that occur anywhere in the country of the eastern seacoast. During the migrations, ducks and geese were seen flying up and down the river, or over Manhattan Island; and a list of the birds would not, I suspect, have differed greatly from a bird list made anywhere else along the coast from Greenwich to Hackensack.

A notable feature of the wild life in this once remote region was the music of the birds, and chiefly the song of the wood thrush, great numbers of which nested among the hem-

locks and white oaks and the undergrowth that stood there. Morning and evening each singing thrush, perched on the stout branch of giant white oak or hemlock—he seems to prefer that to a twig—poured forth his liquid notes, which, clear as a bell, rang out on the quiet air. Some people used to say that the notes of the thrushes of Audubon Park seemed to possess a clearer, more resonant quality than those of others of their kind, and rather sentimentally connected the sweetness of their song with the associations of the place.

The mammals were not many. There were three species of squirrels, of which the red squirrels were most abundant and the grays least so; while, owing to their nocturnal habits, the flying squirrels were seen only occasionally, although actually they were numerous. Trinity Cemetery was then enclosed by a high board fence, painted gray-blue. The horizontal boards were fastened to rough posts which were hidden by two vertical boards nailed on each side of the post and meeting outside it at an angle. In the high triangular chambers thus formed, there was often much space between the post and the boards, and here the flying squirrels used to make their nests. Some one of the boys at last discovered this habit, and after that most of the neighborhood lads maintained for a time a cage of captive flying squirrels, for the little animals were very abundant.

There were many muskrats on the rather extensive tidewater flats and coves of the Harlem River, and in winter, with Jack Audubon, I often went over to these flats to assist at the shooting of the muskrats.

At that time an arm of the Harlem River ran south through what are now the Polo Grounds, about to 145th Street, but east of this arm was a tongue of land which ran up toward McComb's Dam bridge. This is the present Eighth Avenue. Crossing the tidewater flat—in a general way about where the viaduct at 155th Street now runs, but really somewhat south of it—was a little footbridge, two planks wide, the planks resting on slender poles driven into the mud of the bottom. A footpath ran down the very steep hill near where 155th Street now is, and the little footbridge led from this path across to the solid land to the eastward. In this water there were many muskrats, and after ice had formed over it, they resorted to holes in the ice where we watched for them. They were not often killed, but occasionally one was recovered, and very often we believed we had killed one that had gotten away. Jack Audubon was often permitted by his father to carry his grandfather's gun, and he used it on his shooting excursions.

None of the modern streets or avenues was then open, and there were practically no dwellings along the Harlem River above Harlem Village. The steep, rocky bluff which overlooked the Harlem River, between about 150th Street and the High Bridge, was covered with a growth of tall, hardwood trees, chiefly oaks and chestnuts, and in these trees many crows bred as did also woodpeckers, blue jays, and smaller birds. Little screech owls often occupied the holes in trees abandoned by the golden-winged woodpeckers, and on more than one occasion a small boy thrusting his hand into the hole to feel for woodpecker eggs, found his fingers deeply pricked by the sharp talons of the little owls.

Between 158th Street, which was the northern boundary of Audubon Park, and Fort Washington, a mile to the north of that, was a stretch of woods interrupted in two places only by lanes leading from the main road along the ridge down to private dwellings near the river. In these woods were many rabbits, and I have always believed

that on one occasion I started there a ruffed grouse.

At that time, and for many years afterward, there existed near the High Bridge—that is to say, just south of 175th Street, west of Tenth Avenue, and east of the so-called Bloomingdale Road, now perhaps Broadway-Eleventh Avenue—a considerable swamp which possessed a mysterious fascination for the boys of that time and place. Green herons bred there in considerable numbers; that is, we could always find a dozen nests. The birds were tame, for after the novelty of discovery had worn off, the boys seldom disturbed them and they soon became accustomed to the boys. Woodcock bred on the borders of this swamp, and were occasionally seen there and shot at in autumn. South of the swamp, which we called "the green heron woods," was a rather wide extent of pasture land, interruptd by occasional old stone walls and copses of undergrowth, to the point where Tenth Avenue and the present St. Nicholas Avenue cross—about 162d Street. After I had learned how to prepare bird skins, this large triangle was one of my favorite collecting grounds. It was varied in character and was frequented by a multitude of migrating small birds. For many years all this tract has been covered by tall apartment houses.

In this large triangle, which must have been three-quarters of a mile long, I recall but a single building—the old colonial stone structure known as the Cross Keys Tavern. There was a tradition that once Washington had slept there, and when I was a small boy, and perhaps much later, there still swung from a beam projecting out toward the road—west—a large weather-beaten sign on which were painted the two long keys crossing each other which gave the house its name. I cannot recall that it was ever used as a tavern.

During much of the winter the Hudson River was full of ice, on which eagles and crows were constantly seen perched or walking about, feeding no doubt on the refuse and the bodies of animals thrown into the stream farther north. There was a crow roost on a cedar-crowned knoll north—or east—of the Harlem River, but west of the New York, New Haven and Hartford Railroad and south of High Bridge. At daylight each morning the crows flew westward to the Hudson River, and on days when it was foggy or when it was snowing they often flew very low, even among the tree tops. The first crow I ever killed was shot just at dawn from one of the upper windows of the house as it flew over.

Sometimes the eagles from the river alighted in the large trees not far from the house, and at least on one occasion one of the birds dropped a fish which was picked up by the children.

After the small boys of the time were old enough to carry guns, they devoted much of their time at certain seasons of the year to excursions after what they considered game. This game consisted chiefly of small birds, robins, woodpeckers, meadow larks, wild pigeons, and, at rare intervals, a rabbit, or even a duck. In the woods north toward Fort Washington were many dogwood trees, and in autumn when the berries were ripe birds came here in great numbers to feed on the fruit. We used to sit near such trees and shoot the birds, which in due course were brought home and cooked. As we grew older we extended our wanderings farther afield, and worked our way north to Tubby Hook and to Dyckman's Meadows on the Harlem River where small sandpipers and small herons were often to be had, and at rare intervals a duck was found. Wood ducks and black ducks were the largest game the boys ever secured.

A longer excursion was up to Van Cortlandt Lake—the present Van Cortlandt Park, which we then called

"Bronson's." From the lake a stream flowed out toward the Harlem River through a wide marshy meadow, largely overgrown with flags and high grass. This, in autumn, was a resort for blackbirds, and here Wilson's snipe were sometimes started, but the small boys never killed them, nor any of the quail which were often seen, but which flew too fast for us.

One spring day I watched for a long time an osprey repairing its nest in a tall tree on a hill northeast of Van Cortlandt Lake. The nest seemed an old one, for it was very large, and the bird, as it swung over the ground in flight, was picking up bits of sod or of dry grass to use on the nest.

I had been to Van Cortlandt Lake long before these days, for when I was a very small boy two or three of the Audubon Park families had driven up to the lake on an all-day picnic. On this occasion my father, who was a great angler, had followed up a brook running into Van Cortlandt Lake and captured there an enormous trout, perhaps the only large fish in the brook. I should not dare to guess how long or how heavy this trout was, but I remember that it was regarded with astonishment and reverence by the other men of the party who had been less fortunate than its captor.

One autumn, soon after my first gun had been given to me, a woodcock made its appearance in our garden—near what would now be the corner of 157th Street and Broadway—and, until cold weather came, gave me a great deal of shooting. After I had learned that the bird was there I went out into the garden each morning before breakfast, found the bird, and shot at it. Later in the day I sometimes found it again and had another shot. I never hit the bird, but had much excitement in its pursuit.

Until as late as 1890 or 1895, quail and woodcock occasionally made their appearance in Audubon Park. The presence of the woodcock was always explainable, but I never was quite clear in my mind as to where quail came from.

Up to the time when that portion of Audubon Park east of Riverside Drive was swallowed up by the city—1909—two or three broods of little screech owls were reared each year in the great trees that grew in the place. From the piazza and the front windows of the house, in summer, the little owls might be seen almost any day dozing in the holes in the trees or on the branches. Now and then the children would find on the lawn a downy young owl that had fallen from a nest, and the work of returning the fledgling to a place of safety was always an exciting task for the children and for the parent birds.

The long-eared owl was occasionally seen on and near the place, and it was reported that the barred owl bred in the woods south of Fort Washington, although I knew nothing more than the report. In winter the snowy owl occasionally appeared, and the saw-whet owl was another winter species.

Up to 1909 golden-winged woodpeckers bred in some of the large trees on the place and it is quite possible that today some of these birds may breed in the Trinity Cemetery near by.

Such winter birds as the red and the white-winged crossbills and the snow bunting were occasionally seen, the crossbills as late as 1895–96, when a flock was observed one Sunday hard at work on the cones of a hemlock tree close to the house. A bird seen in winter, but not a winter bird, was a cardinal grosbeak, which made its appearance in February, 1867, on a small dogwood tree close to the house.

Wild—passenger—pigeons were seen each autumn at this point, and the boys used to have not a little excitement in shooting at them from the top of the house as they flew over

north and south. It was discouraging work, for they really flew too fast to be hit, yet occasionally we got one. Many ornithologists will remember an article which appeared about thirty years ago in *The Auk,* from the pen of the veteran ornithologist, George N. Lawrence, which described conditions as he had found them at Manhattanville, not many years before the time of which I am writing.

New York has been spreading out and exterminating wild life for nearly three centuries. Thirty or forty years before 1860 the Lispenard Meadows afforded good snipe shooting, and in what are now Tompkins Square, Central Park, Broadway from about 46th Street to the North River, and Fifth Avenue at 32d Street, there was good woodcock and rabbit shooting. The growth from small population to great has taken place too often in American cities to cause us much surprise. Our larger wild life has for the most part disappeared, and population has increased so rapidly and territory has been so generally occupied that such changes will be less startling in the future than they are today.

As transportation facilities increased between the southern and the northern portions of Manhattan Island, population spread northward, and with a growing population, conditions became less favorable to the existence of wild life in upper New York. Broadway was opened in this region about 1874, I think, and somewhat later the elevated railway brought a host of people northward. Nevertheless, it was not until after 1900 that the wild birds became notably fewer. But, after the completion of the subway, the march northward of the tall buildings began, and the transformation was rapid.

House on the Hudson about 1842 where lived John James Audubon, between what are now 155th and 158th Streets and Amsterdam Avenue (From title page of *Audubon, the Naturalist of the New World.* By Mrs. Horace St. John, 1856). In the generation after Audubon the region was known as "Audubon Park." The conditions all about were those of the country, with the city six or seven miles to the southward. The music of wild birds was especially notable; many people influenced by the associations of the place used to say that the songs of the wood thrushes of Audubon Park possessed a sweeter, more resonant quality than anywhere else. Broadway was opened through about 1874; later, the elevated railway brought the population northward. As late as 1890, however, quail and woodcock appeared; in fact, not until about 1900 did the number of wild birds greatly decrease, but finally, about 1909, the city having completed the subway and covered the land with tall buildings, Audubon Park and its wild life were swallowed up

FLANKED BY MOSS-GARLANDED CYPRESSES

The Cowhouse Run is one of the fairest spots in the entire Okefinokee. It passes between colonnades of cypress trees festooned with swaying gray tillandsia. The surface of the run is almost shut from view by water lilies and "never-wets" (*Orontium*) which scrape against the boat as we pole it through them.

To convey by pictures or words any conception of the unusual beauty of this southern swamp is impossible, and to wander through it is an adventure quite apart from all the ordinary experiences of life.

Considerable scientific study has been done in Okefinokee during the last ten years, especially by the United States Biological Survey and the scientific departments of Cornell University. There is no more suitable area in the eastern United States for an outdoor biological station. Here a study of life histories and ecological relations can be carried on in undisturbed primeval conditions

Okefinokee Swamp as a Reservation

By FRANCIS HARPER

Assistant Biologist, United States Biological Survey

THE famous Okefinokee, "the greatest natural wonder" of Georgia, covers nearly seven hundred square miles in the southeastern part of the state, between the city of Waycross and the Florida line. Among the fresh-water swamps east of the Mississippi, it is exceeded in size only by the Everglades; and in the richness of its historical and literary associations, in the marvelous beauty and charm of its diversified scenery, and in its extraordinary interest as a faunal and floral area, Okefinokee Swamp is unique. It has no counterpart anywhere in the world.

There are several respects in which the swamp would make a particularly useful and valuable reservation under federal or other auspices. It is a refuge for some exceptionally rare forms of animal life. It is an important wintering ground for large numbers of migratory waterfowl. It still contains, in spite of extensive lumbering operations, about five hundred square miles of diversified territory in an absolutely primeval state, offering to naturalists unsurpassed opportunities for faunal and ecological studies. Moreover, it has a distinct æsthetic value; the extraordinary beauty of its scenery makes a strong appeal to all lovers of nature who have been privileged to visit the region. Professor James G. Needham has characterized a scene on Chase Prairie as "one of the most remarkable landscapes in the world."[1] If the destruction which now so direly threatens the swamp is permitted to be carried out, one of the most interesting natural features of our country will be lost forever.

While the Okefinokee has enjoyed historical and literary renown for more than a century, it is only within a comparatively few years that its biological features have been systematically investigated by men of scientific training, and that the published results of their work have begun to appear.[2]

The Animal Life of Okefinokee

In the eastern United States there is certainly no area of equal extent which affords such exceptional opportunities for the study of animal life in a primeval environment as does Okefinokee Swamp. With the rapid destruction of natural conditions over the entire country, it is of the utmost importance, from the standpoint of science, that at least a few areas here and there should be preserved in their original state. The following notes touch upon just a few of the rarer or more interesting forms among Okefinokee's marvelous wealth of animal life.

There are probably between one and two hundred black bears in the swamp and its immediate environs; the Florida deer is a rather common and well-distributed species on the islands and in other parts of the swamp; the Florida otter is a fairly common denizen of this wilderness; several panthers have been recorded about the borders within the past few years; a Florida wolf was killed near the edge of the swamp about 1910; and some animal believed to be a wolf was heard in the swamp several times in 1916. This species is virtually extinct, and there are only one or two specimens in the museums of the country. That curious little animal, the

[1] James G. Needham and J. T. Lloyd, *The Life of Inland Waters*, Ithaca, 1916, p. 93. For a general description, history, and map of the swamp, cf. Wright and Harper, *The Auk*, XXX, October, 1913, pp. 477–505.

[2] See the appended bibliography.

The illustrations are from photographs by the Author.

Florida water rat or round-tailed muskrat (*Neofiber alleni*), has just recently been discovered in the swamp. It is very abundant here in its only known habitat in Georgia.

The ivorybill, our greatest and most magnificent woodpecker, now on the very verge of extinction, has maintained in the Okefinokee one of its last strongholds. The Minne Lake Islands, its principal haunt, were reached by lumbering operations about two years ago, and the few remaining birds may have been driven to some other part of the swamp. The great pileated woodpecker, scarcely less splendid than the ivorybill, is astonishingly abundant, its numbers here perhaps surpassing those of any other part of the country. The American egret, once nearly exterminated for its plumes, has been found breeding in the environs of the swamp. It also has here a safe winter refuge. Late one January afternoon I beheld about eighty-five of these birds winging their way, singly and in bands, over Floyd's Island Prairie toward their roost. The Okefinokee is the only place in Georgia where one may find the sand-hill crane and the limpkin. The former is a resident and quite common species, but only one or two of the curious and fast-disappearing limpkins have been observed in the swamp, which doubtless represents the northern limit of their breeding range. The wood duck is a resident species of which there are probably hundreds of individuals in the swamp. In the entire country there is perhaps no other equally favorable habitat for this rare and beautiful little duck.

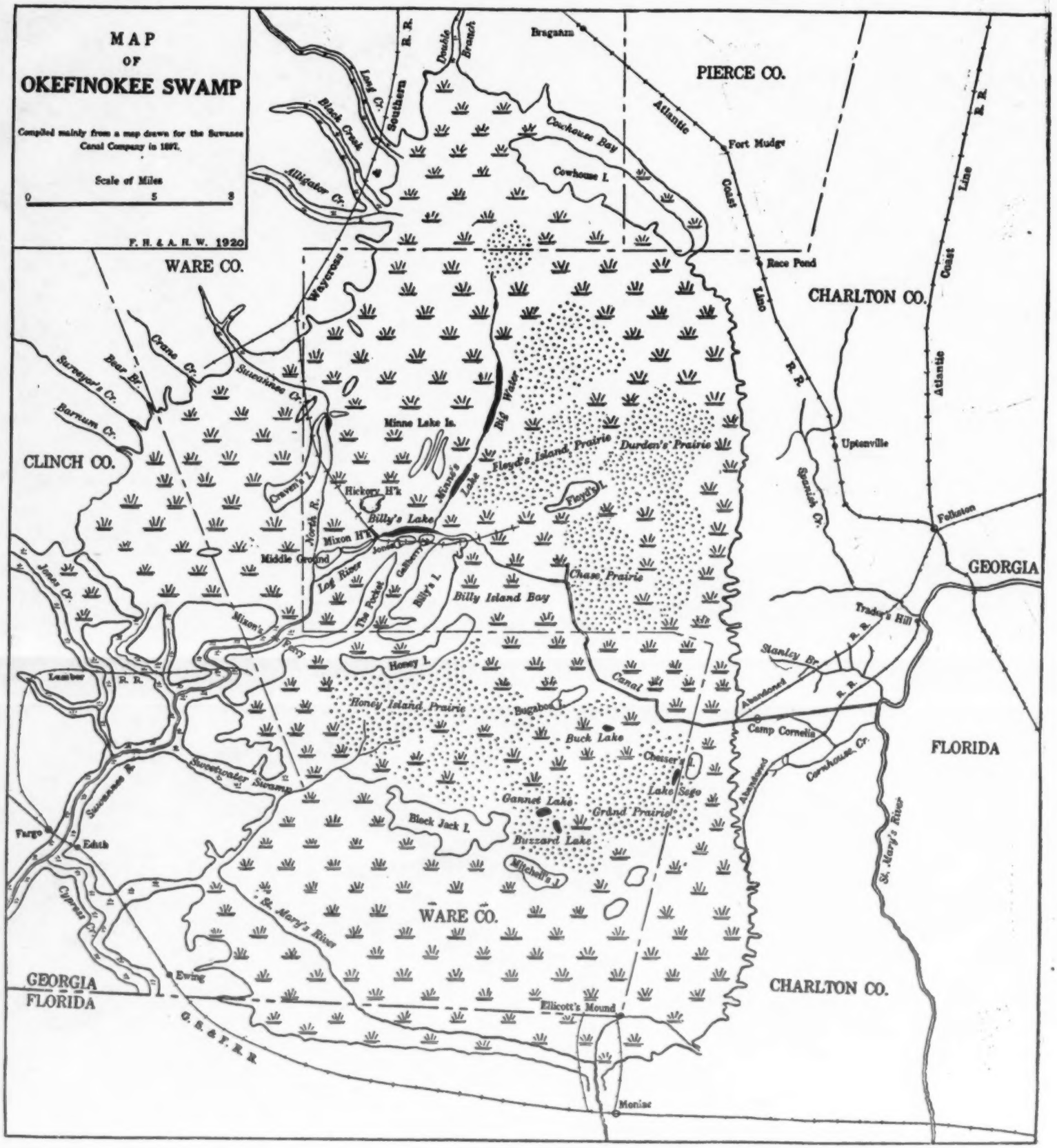
As a wintering ground for migratory waterfowl, the Okefinokee is of very considerable importance. Eleven species of interest to game conservationists were found wintering in 1916–17, in numbers loosely estimated as follows: hooded merganser, several hundred; mallard, several thousand; black duck, 1000; green-winged teal, 25; pintail, 50; wood duck, 500; ring-necked duck, several hundred; sand-hill crane, 100; woodcock, 100; Wilson's snipe, 500; killdeer, 100.

The conditions here compared very favorably with those in eastern and central Florida in the winter of 1916–17. Mallards, black ducks, and wood ducks then seemed relatively much more numerous in the Okefinokee than in those parts of Florida. Altogether about eighty-five species of birds have been recorded from the swamp in summer, and about ninety in winter. At the latter season it attracts great numbers of berry- and fruit-eating birds.

At present a considerable amount of hunting is carried on, chiefly by residents in and about the swamp. Deer, bears, and wildcats are hunted with hounds at virtually all seasons of the year. Not only the ordinary game birds, but also such species as the wood ibis, Ward's heron, sand-hill crane, and occasionally even a cormorant or a water turkey, are killed and eaten. The wood duck, although protected by both state and federal laws, is killed in considerable numbers; some have been sold in recent years at the rate of three for a dollar. Wild turkeys are now much scarcer than formerly, but their numbers might be restored by proper protection. Bobwhites are still common.

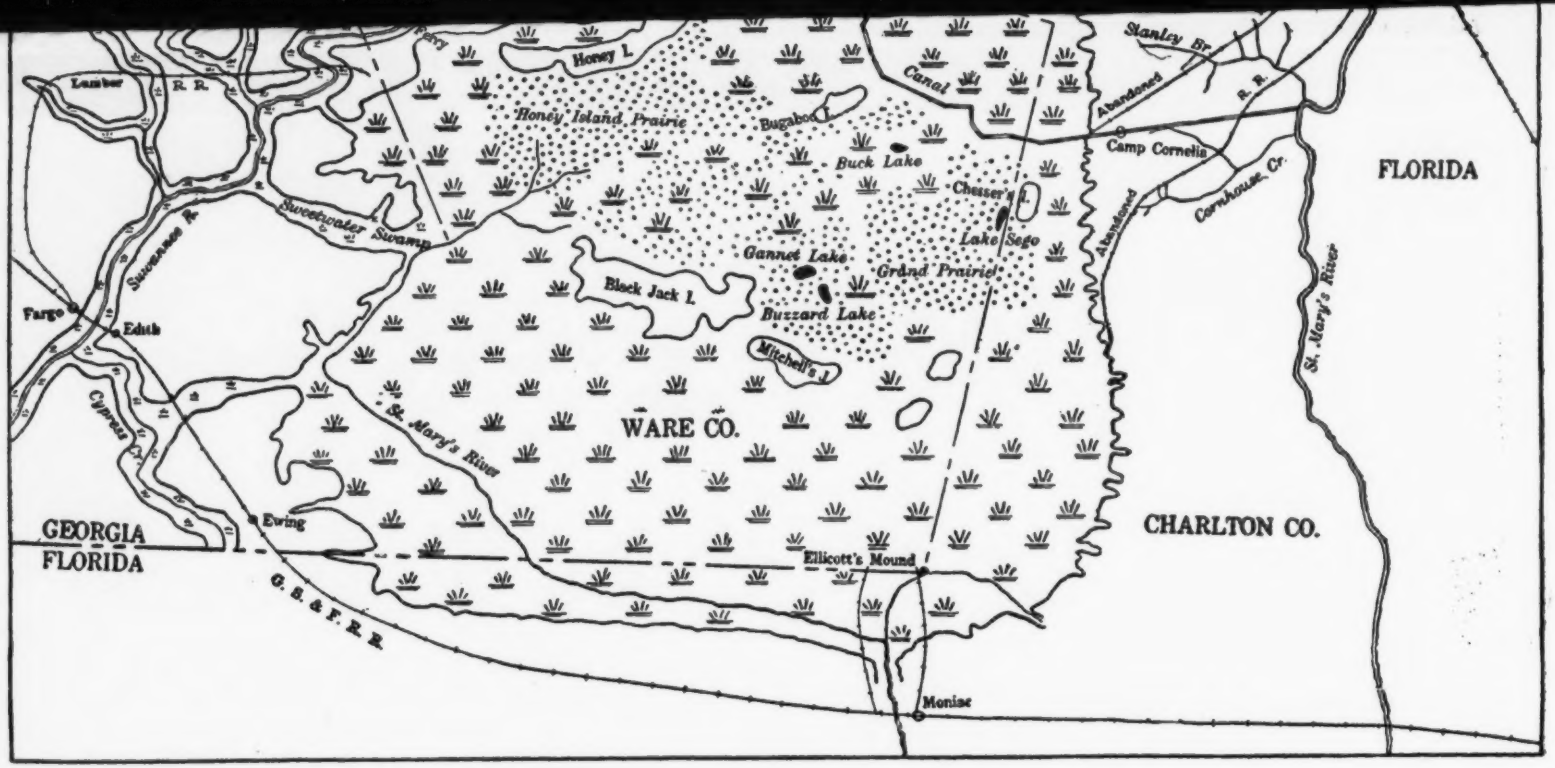
Trapping is extensively practiced. Great numbers of raccoons and several dozens of otters are taken every winter. Smaller numbers of wildcats, opossums, and skunks are trapped.

The Mississippi alligator, now rapidly disappearing from the haunts of man, has found the Okefinokee a goodly place in which to survive. This reptile was formerly killed in large numbers, but during recent years the hides have brought so little in the market that the hunting has practically stopped. For the student of herpetology the region holds a vast and fascinating store of riches.



A REGION OF EXTRAORDINARY SCIENTIFIC VALUE

Okefinokee Swamp in southeastern Georgia is one of the greatest natural wonders of North America. It has been known to white men since the eighteenth century, but intimate knowledge of the interior is relatively recent, and scientific study of the region has been undertaken only in the last few years. In 1889, when timber was relatively plentiful throughout the country, the swamp was sold by the state to a lumbering syndicate for 26½ cents an acre. This syndicate dug the canal and laid the



A REGION OF EXTRAORDINARY SCIENTIFIC VALUE

Okefinokee Swamp in southeastern Georgia is one of the greatest natural wonders of North America. It has been known to white men since the eighteenth century, but intimate knowledge of the interior is relatively recent, and scientific study of the region has been undertaken only in the last few years. In 1889, when timber was relatively plentiful throughout the country, the swamp was sold by the state to a lumbering syndicate for 26½ cents an acre. This syndicate dug the canal and laid the now abandoned railway to Camp Cornelia. During the last ten years about one third of the swamp, including the important islands except Floyd's, Black Jack, and Mitchell's, has been cut over or turpentined. These three islands constitute one of the last stands in Georgia of virgin long-leafed pine (*Pinus palustris*).

The Okefinokee Society has been organized to preserve this unique region for "public, educational, scientific, and recreational uses" and proposes to purchase a representative portion of the swamp, if sufficient funds can be obtained, and to present it to the United States Government for administration as a wild life refuge

The Okefinokee is a refuge for such rare and splendid birds as the ivory-billed and pileated woodpeckers, the wood ibis, the sand-hill crane, and the American egret. Seven species of ducks are found wintering here: hooded merganser, mallard, black duck, green-winged teal, pintail, wood duck, and ring-necked duck. In the somber depths of the cypress "bays", about the first of June, we may find the nest of the Acadian flycatcher, which delights in the solitude of the moss-draped trees above the clear, brown water. The photograph presents a scene just north of Billy's Lake

The photograph below shows the abundance of huckleberries on Billy's Island—an important element in the food supply of both birds and mammals

VIEW OF CHASE PRAIRIE FROM A TREE TOP

The vast open marsh of Chase Prairie, interspersed with pine heads—"one of the most remarkable landscapes in the world"—calls through its sheer wildness to the naturalist and hunter alike for protection and preservation. The call must be answered quickly, however, or the swamp will be stripped of its rich vegetation and drained for dry farm land of doubtful value

SO MAY HAVE LOOKED THE HAUNTS OF THE DINOSAURS

Above the surface of the "prairie" rise purple bladderwort flowers, and white water lilies bloom in myriads. Over beds of quaking sphagnum wind trails of otter and alligator. The rare wood duck hides her young among the yellow pond lilies, and the water turkey soars in wide circles or plunges headlong into the tepid water

The swamp waters abound in fish life, including pickerel, large-mouthed black bass and other smaller bass, short-nosed gars, chub suckers, mudfish (*Amia*), various species of catfish, and numerous killifishes. Among the recent discoveries is a particularly dainty little fish, *Lucania ommata,* which was previously known only from a few specimens taken in Florida; it enjoys the distinction of being one of the very tiniest of existing vertebrates.

The Plant Life of Okefinokee

The wonderfully rich and diverse plant life of the Okefinokee constitutes one of its greatest charms and beauties. And herein one may perceive a veritable illustration of the "curse of beauty"; for it is the magnificent timber of the swamp that furnishes its commercial value and has invited destructive exploitation. There are two major types of forest growth—the pine barrens on the islands, and the cypress "bays" occupying inundated portions of the swamp.

The so-called pine barrens are open forests of long-leaf and slash pines, between whose straight and lofty trunks one may look for a distance of a quarter of a mile in almost any direction. The low undergrowth consists principally of saw palmetto, together with a profusion of huckleberries and blueberries, which form an important element in the food of many birds and mammals. One may find on some of the Okefinokee islands, where the "turpentiner" and the logger have not yet penetrated, the southern pine forest in its finest glory.

In the "bays", which cover a large portion of the swamp, the dominant growth is the pond cypress. Probably nowhere else in the world does it attain a heavier growth or finer proportions. Other trees in this habitat are

The shallow waters of Okefinokee Swamp afford opportunity for this singular and primitive method of night fishing, or "striking," with a homemade machete by the light of blazing pine torches. The fisherman moves stealthily with upraised weapon ready to strike any fish—pickerel, gar, bass, or catfish—which may be revealed by the flaring light

the black gum, red bay, white bay, sweet bay, and red maple. Every tree is draped with luxuriant festoons of hanging moss. Among the thick undergrowth in the somber, impressive depths of the "bays," there is a handsome little evergreen shrub, *Pieris phillyreifolia,* which usually starts at the base of a cypress tree and works its way upward between the inner and outer layers of the bark, sometimes reaching a height of forty feet, and sending out branches with leaves and flowers every few feet. This manner of climbing is quite without a known parallel in the whole vegetable kingdom.

The so-called "prairies" of the Okefinokee are one of its most remarkable features. They are essentially marshes, with more or less open water, but filled for the most part with a luxuriant growth of aquatic plants—water lilies, maiden cane, pitcher plants, arrowhead, arrow arum, saw grass, fern, paint root, sphagnum, and many others. They are the favored resort of waterfowl and other especially interesting forms of animal life. Here and there on the prairies stand picturesque clumps or "heads" of cypress and pine.

There are a number of other distinct types of vegetation in the swamp, including hammocks, "sand scrub," sphagnous bogs, and cypress ponds, each with a charm of its own. To behold the marvelous array of natural scenery in the Okefinokee wilderness is something apart from all ordinary experiences. It is all but impossible to convey in words an adequate idea of its exquisite, primeval beauty, or of the emotions it inspires. Practically every piece of literature on the swamp, from William Bartram's account of this "most blissful spot of the earth" to Will Henry Thompson's fine appreciation,[1] reveals something of the singular fascination that the place holds for those who have been so fortunate as to gain intimate acquaintance with it.

[1] See appended bibliography.

The Swamp as a Field for Biological Investigations

During the last ten years the swamp has been utilized as a field for biological reconnaissance work by several of the scientific departments of Cornell University, and it has been further investigated by the United States Biological Survey. Reports on the birds, reptiles, and some of the insects have already been published, and reports on the mammals, amphibians, fishes, and plants are in course of preparation. These reports are largely of a preliminary nature, and should form the basis for a vast amount of further and more detailed biological work extending over many years. It is safe to say that there is no area of equal interest, importance, and suitability in the eastern states for the carrying on of such investigations. The Okefinokee would be an ideal location for a field biological station for the universities, museums, and other scientific institutions of the country. And its whole tremendous value for this purpose—the study of life histories and ecological relations—depends on the preservation of natural conditions.

The late war has demonstrated for all time the necessity for scientific research. Since the opportunities that the Okefinokee presents for the investigation of the laws of nature are alike unequaled and unlimited, is it not a national duty to preserve it?

In connection with its potentialities as a great outdoor biological laboratory, as a game preserve, and as a national park, it is perhaps worth while to remark that the swamp is an exceptionally healthful region.

Commercial Operations in Okefinokee

For ten years past the very existence of the Okefinokee, in any condition worth preserving, has been threatened

The shallow boat is more easily poled than paddled through the rank vegetation of the "prairie." Okefinokee is an ideal haunt for the alligator, which is holding its own here, although rapidly becoming extinct elsewhere in the United States. The photograph was taken on Cowhouse Prairie, a place of solitude and grandeur

A camp among magnolias and live oaks in Floyd's Island Hammock.—The zoölogist in Okefinokee has opportunity to study many mammals in their original environment. Besides deer, black bears, and wildcats, with an occasional panther, and even the virtually extinct Florida wolf, there are in abundance raccoons, opossums, otters, round-tailed muskrats, and skunks

The Big Water stretches between shoreless margins flanked by walls of cypress. Here one may paddle with ease for miles along the aisle of clear and quiet water, discarding the forked stick with which the boat is poled through run and prairie

An otter hunter and his trained assistant.—The hound on scenting an otter jumps overboard and pursues and attacks the quarry in its own element. He gets in this way more pelts for the hunter than could be obtained with traps. Considerable hunting of deer, bears, and wildcats with hounds goes on in and about the swamp, although such game becomes scarcer year by year. With proper protection, the Okefinokee would prove a hunter's paradise

by rapidly extending commercial operations, until matters have now reached an acute stage. One lumber company, with a great mill near Waycross, has already removed the heavy cypress timber in the northwestern quarter of the swamp, between Suwannee Creek and Billy's Island. The company's railroad, with many branches, now extends to the very heart of the swamp between Billy's and Floyd's islands. Another company has turpentined the magnificent pines on Billy's Island and the Pocket. Thus the area already devastated probably comprises more than one hundred square miles; and there is a constant menace of industrial encroachment from all sides of the swamp.

Fortunately, the entire area in which the removal of the timber either has been accomplished or is being planned, comprises only about one third of the swamp. This lies mainly in the northwestern part, extending south to Honey Island and east to Minne's Lake; and also through the "bay" northeast of Billy's Island to Floyd's Island. In most other parts of the swamp the timber is too small or too scattered to be worth cutting by the present methods. It is most unfortunate, however, that so many of the islands have already been devastated, and that nearly all the rest are marked for destruction.

As this is being written, word comes that operations are on the point of being extended to Honey Island, for the sake of its pine resin and timber; and there appears to be no available means of saving this wonderful bit of the Okefinokee. In the course of two or three years the same fate awaits Black Jack and Mitchell's islands. The pine forests covering these islands, about three thousand acres in extent, constitute practically the only merchantable timber in the entire southern portion of the swamp. Furthermore, in the recently expressed opinion of a prominent lumberman, they are among the last remaining areas of "unboxed" long-leaf pines in the whole state of Georgia. At the prevailing price of lumber it will require no small sum to preserve these islands as rather solitary types of the primeval long-leaf pine forest. Floyd's Island, in the eastern part of the swamp, is the most diversified, and in some respects the most interesting, of the islands. The owners have kept it as a sort of game preserve, and it is evidently in no immediate danger of exploitation.

Even if all the merchantable timber were cut, the large portions of the swamp remaining untouched would still form a valuable wild life refuge as well as a noteworthy and useful field for scientific investigations. There is, however, another menace, which, unless warded off in time, bids fair eventually to destroy the last vestige of interest or value which the Okefinokee holds for nature lovers. This, in brief, is drainage. Plans are already being considered for a definite system of drainage operations, to be started after the timber has been taken out, for the purpose of converting the swamp into land suitable for agricultural purposes. On the other hand, the great cost of the undertaking, as well as the uncertain value of the land after being drained, is a factor which lends encouragement to those who make bold to consider the Okefinokee prairies a greater national asset in their present state than in any other.

The Okefinokee Society

The Okefinokee Society was organized in 1918, its object being "to give authentic publicity regarding the Okefinokee Swamp; to secure its reservation and preservation for public, educational, scientific, and recreational uses." One of the most encouraging features of this movement is the fact that it originated through local sentiment in Waycross, Georgia. The citizens here recognize the scientific and

THE FASCINATION OF THE BOGS OF OKEFINOKEE

There is no line where one may say the land ends and the water begins. In the "strand" between Billy's and Honey islands the hunter totters over trembling beds of floating sphagnum or sinks waist-deep into the oozy muck, while his bearhounds half swim, half wade, through the bog. Okefinokee—"Trembling Earth"—the Indians realistically named the swamp

historical interest of the swamp, its scenic wealth, its recreational advantages, and other phases of its many-sided attractiveness, and may be depended upon to help safeguard its welfare and usefulness when it is made into a reservation. The society has the hearty endorsement of the National Parks Association, the United States Biological Survey, the American Museum of Natural History, the National Association of Audubon Societies, the Ecological Society of America, the American Game Protective Association, the State Geological Survey of Georgia, the Cornell University Departments of Zoölogy and Entomology, and many scientists and nature lovers throughout the country. The president of the society is Professor James G. Needham, of Cornell University, and the secretary, Dr. J. F. Wilson, of Waycross, Georgia. All lovers of wild life and natural beauty may do their bit for the cause by becoming members of the society and keeping posted on its activities.

One of the first aims of the society is to secure certain representative portions of the swamp as the nucleus of a reservation, to which additions may be made as rapidly as opportunity or funds permit. The prospects of state or federal aid, especially in the immediate future, are quite uncertain. Therefore, at the present critical stage in the history of the swamp, the one certain way of preserving at least a part of the Okefinokee in a natural state is by the use of sufficient private funds. The Okefinokee Society is accordingly prepared to undertake the raising of such funds. The society plans, after securing the area for a reservation, to present it to the United States Government, in order that it may be administered and perpetuated as a national wild life refuge. In conclusion the complete commercial exploitation of Okefinokee Swamp would be an incalculable loss to science and to the nation, just as its preservation in its present state would be a lasting benefit to the whole country.

Two of the three great swamps of the Atlantic seaboard, the Dismal Swamp and the Everglades, have already been changed by man beyond the hope or possibility of preservation in a natural state. Let us act now, before it becomes forever too late, in behalf of the Okefinokee.

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LONG-LEAF PINES ON BILLY'S ISLAND, OKEFINOKEE

The origin of the name "Billy's Island" carries back through the romantic history of the Okefinokee. From the island's seclusion Billy Bowlegs, Indian Chief, defied the armies of the United States which sought to remove the Seminoles from the land of their fathers.

In recent years Billy's Island was the home of pioneers who, in the freedom of the wilderness, drew a plentiful, if somewhat primitive, livelihood from its manifold resources. Its sandy loam produced their crops of corn and sweet potatoes, while deer, bears, raccoons, opossums, rabbits, squirrels, fish, soft-shelled turtles, and wild turkeys supplied the viands for their table, and the pelts of alligators, bears, wildcats, and otters furnished a medium of exchange with the outside world. Out of the tops of the pines growing about the cabins of these pioneers, sometimes, in the absence of the men, the women shot black bears after they had been treed by the dogs

THE EARTH'S SPRING CHOIR

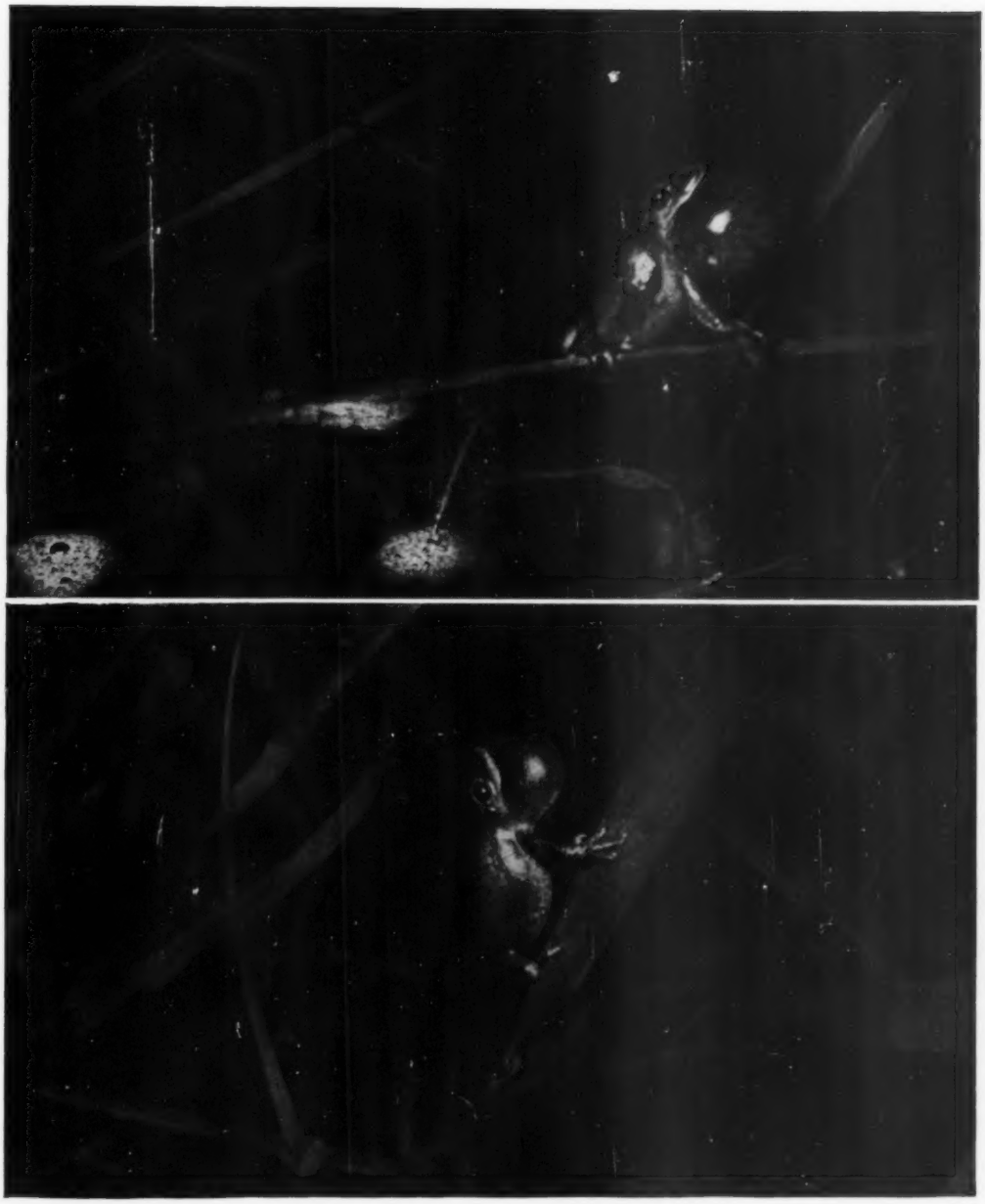
WITH PORTRAITS[1] OF SOLOISTS AND CHORISTERS PHOTOGRAPHED AT NIGHT BY THE AID OF FLASH LIGHT

BY FRANK OVERTON

IN MARCH AND APRIL JOYOUS PIPINGS PROCEED FROM EACH SMALL WOODLAND POOL

[1] The quite marvelous and wholly unique photographs from life by Dr. Overton, which it is a great satisfaction to reproduce in NATURAL HISTORY, represent eleven species of toads, tree frogs, and frogs. The pictures were taken during a period of ten years about the ponds and marshes of Long Island, New York—with the exception of that of the American toad. They could be taken, of course, only in the early spring months, and as the animals are for the most part nocturnal in habit, only at night. They cover the entire Salientian fauna of the northeastern and middle eastern United States, with the exception of the northern mink frog, *Rana septentrionalis* Boulenger, the tree frog *Pseudacris feriarum* (Baird), which finds its northern limit in New York and Connecticut, and the two local races, *Hyla andersonii* Baird and *Rana virgatipes* Cope, of the New Jersey and Carolina coastal area.

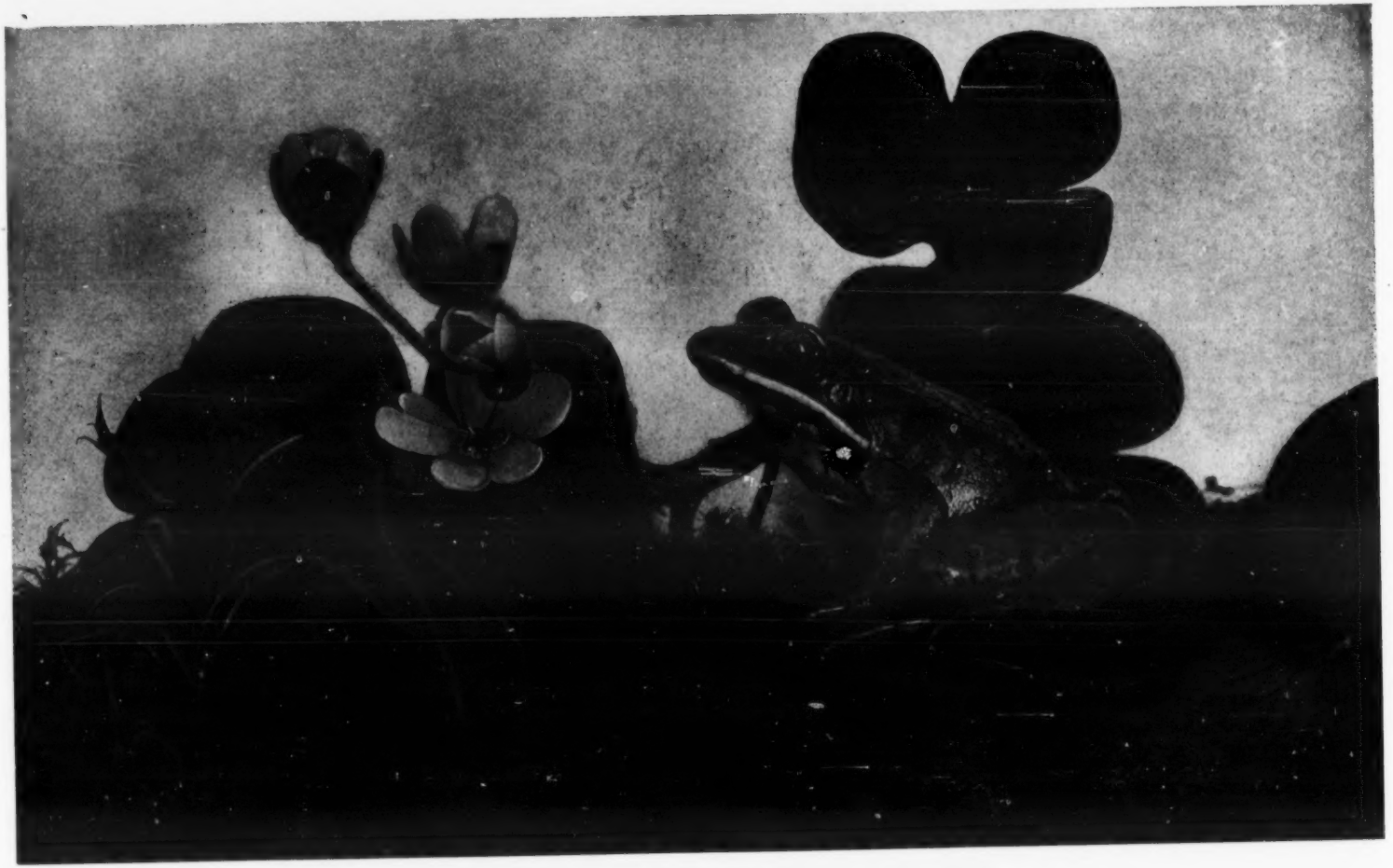
The records of air and water temperatures and in most instances the times of first appearance are from the research work (*North American Anura*, 1914) of Dr. Albert H. Wright, of Cornell University, and for the latitude of Ithaca, New York.



SPRING PEEPERS "BLOW THEIR BUBBLES"

If voice among the Salientia were proportionate to size we should judge on hearing the call of the spring peeper (*Hyla crucifer* Wied) that it came from a very large frog instead of from a tiny creature an inch or less long, often little larger than one's thumb-nail. The peeper sings from concealment by day. We may stand motionless on a tussock of grass out in the marsh, while the sounds come from right and left, even from about our very feet, and search long and diligently without seeing one of the singers. But at night they clamber and swim about and are easy to locate by their voices. Like all other toads and frogs they are not afraid of the lantern. They continue enthusiastically to "blow their bubbles" in face of it, or even during the explosion of the flash light. What looks like a bubble is a throat pouch, so thin-walled that it is transparent, which the frog can distend with air through openings in the mouth (which is kept closed). The pouch acts as a resonator to increase the volume of the sound.

The peeper usually appears in late March, the first species to come from hibernation. It is inured to an air temperature as low as 41 degrees Fahrenheit, with average maximum temperature about 51 degrees. Peepers remain in the water many weeks before they scatter over the ground of the woods and meadow. The chorus is likely to be at its loudest about the first of May. The calls are high-pitched, clear, and penetrating, often carrying on the night air over open level country for nearly half a mile. Each call consists usually of two tones, the first lower, and sliding into the second. The calls of the different singers alternate irregularly in a loud jangle like that of sleigh bells



ONE OF THE EARLIEST TO AWAKE FROM HIBERNATION

The delicately modeled wood frog, *Rana sylvatica* Le Conte, is one of the smallest (two inches long) of the genus *Rana* in North America. It is adapted to the same low air temperatures as the peeper, and comes out from its winter sleep under logs, dead leaves, and moss in the woods in late March or early April, almost simultaneously with the little *Hyla* and the leopard frog, or at least only a few days afterward. It immediately finds its way to the pond—which probably is the pond of its ancestors—and its croaking becomes a conspicuous sound of the night

RIPPLES CIRCLE OUT AS THE THROAT AND VOCAL SACS EXPAND

The wood frog croaks while floating and swimming; the individual call is short and explosive. A chorus heard at a little distance—it does not carry far—may sound like the clucking of barnyard ducks. At this early season the only frog calls to be heard with which the wood frog's croaking might be confused are those of the leopard, which are much louder, more prolonged, and lower in pitch. After a few days in the pond, wood frogs leave the water not to return to it until another spring. They live in the shade of trees and shrubs among the dead leaves, mosses, and wild flowers that carpet the woods floor, burrowing underneath if the surface drought becomes great and when the cold of late autumn comes. The tadpoles develop into the adult form the first summer, as do those of the pickerel and leopard

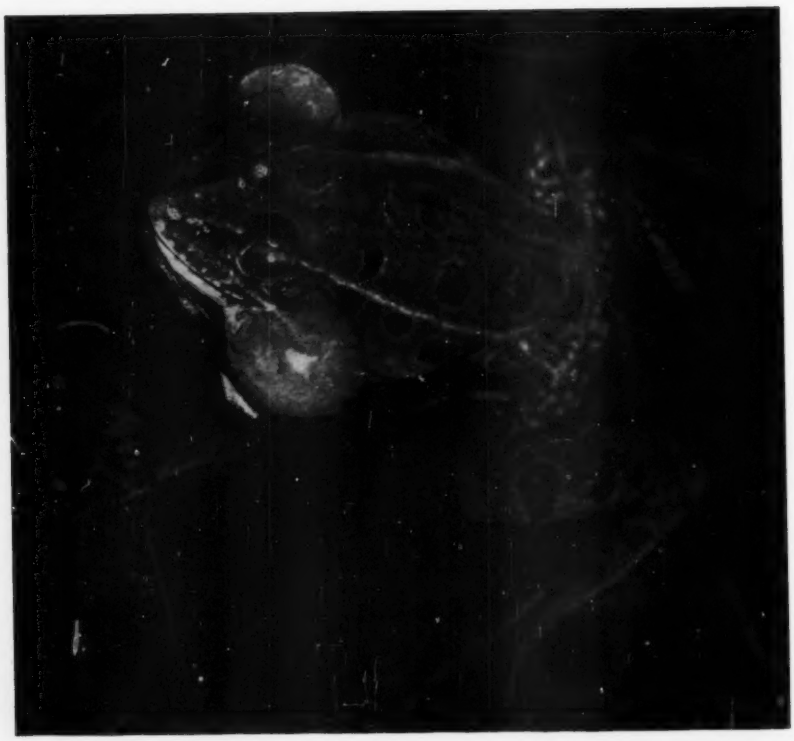
A FROG THAT OFTEN SINGS SUBMERGED

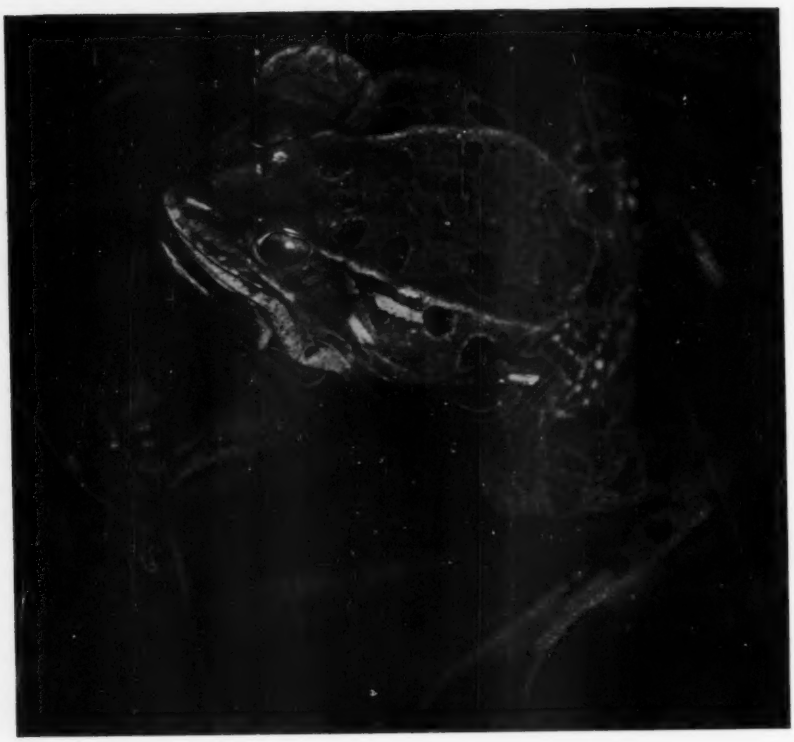
This, like the toad, is a great ally of the farmer, and it is our most common frog in North America, the leopard frog, *Rana pipiens* Schreber, yet few of us have ever seen it croaking. It often gives its prolonged snoring notes from the bottom of the shallow pond (agreeing in this with pickerel and green frogs). The leopard frog's voice is especially musical in quality; the croaking may be roughly imitated by vocalizing deep in the throat the two syllables, "ker-rock," or rather "ker-r-r-r-ock." If the frog sings submerged, of course the nostrils are kept closed as well as the mouth, while air is forced through the vocal cords back and forth between the lungs and the vocal sacs. These, like two great bubbles, alternately swell out and collapse at the sides of the head.

The leopard frog is adapted to the same low air temperatures as peeper and wood frog, and appears in late March almost simultaneously with them (usually between the two), although its voice may not be heard until a week later, when the temperature has risen to about 50 degrees. Frogs are less highly developed for life on land than toads and are more dependent on the presence of water, yet the leopard lives for long periods during the summer and fall months wandering through meadows and fields, along the roadways, or even into gardens in search of insects

THE HUMBLEST MARSH IN SPRING INVITES STUDY

Probably most people know that the conspicuous choruses of sound that issue in spring from wet meadow or marshland, pond or river margin, are made by frogs or toads of some sort. But perhaps not a large number of people recognize the notes of the different species and know what each singer looks like—which is so common a knowledge in our country in regard to the birds. The pleasure and satisfaction are not small, however, that come to those who do know them—especially if the knowledge has been gained clue by clue each spring by personal original investigation—in the spirit that Louis Agassiz taught





CROAKING LEOPARD FROG

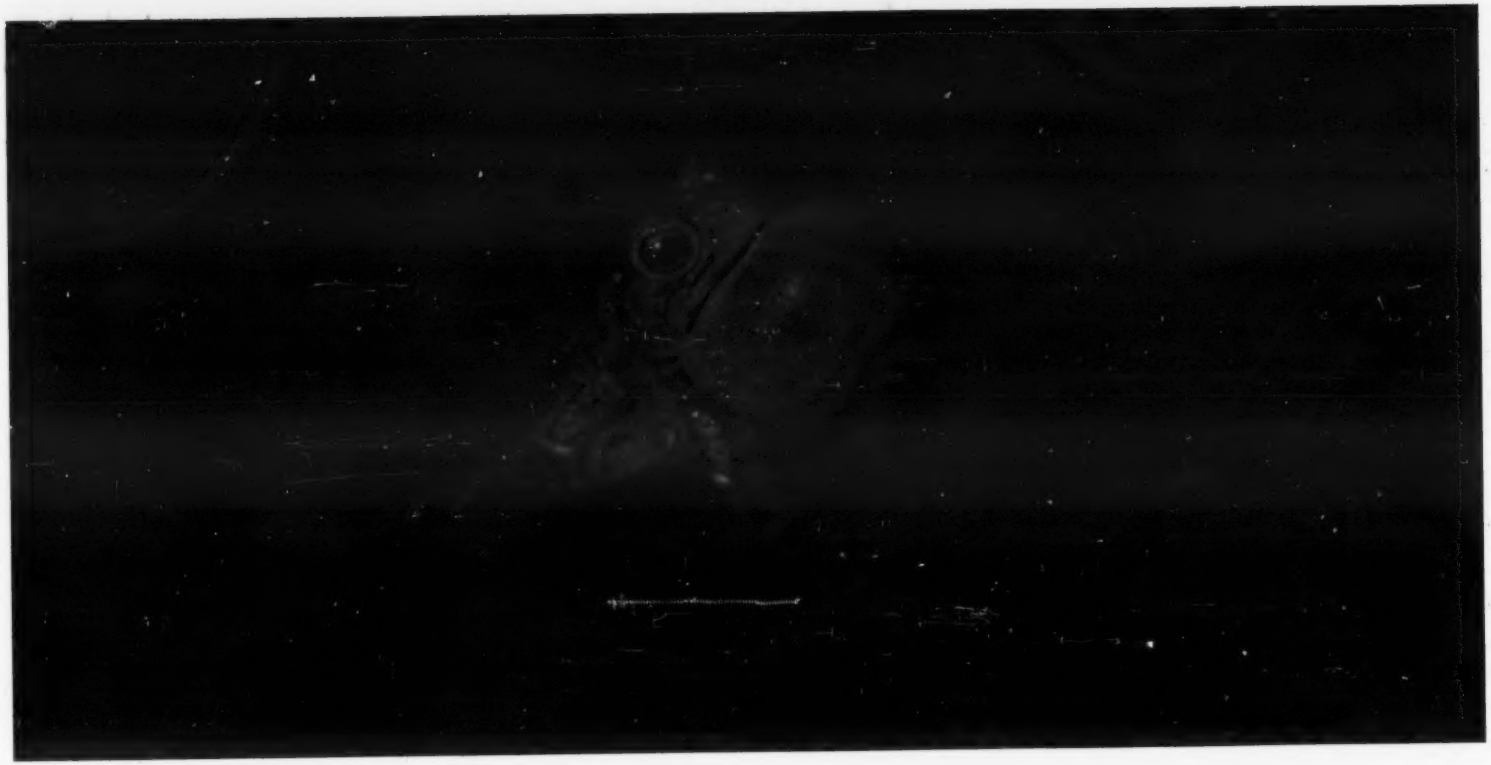
With vocal sacs distended (photograph above) as the call proceeds, and collapsed (below) as it stops

There are three great groups of musicians among the earth's creatures, lower than mammals, performing at different seasons of the year: the Salientia, or toads and frogs, singing in early spring, birds making up the great chorus of song in late spring and early summer, and instrumentalists (Orthoptera and cicadas) among insects performing in vast orchestras during the summer and autumn. We are not surprised at the work of these insect instrumentalists, for evolution has carried these small creatures of instinct so far that their complexity of structure and behavior taxes the interpretation of man; besides, in no case has there been developed among insects a true voice. Neither are we surprised at the high perfection reached by the whistling, singing voice in the race of birds. It is paralleled by many other items of bird structure and behavior quite as wonderful. That the frogs and toads, however, still showing, by a greater or less dependence on moisture throughout their existence and by metamorphosis from an aquatic larval stage, their rise from fishlike and other voiceless aquatic forms—that these lowly creatures should have any considerable development of true vocal powers is one of the marvels of evolution. And the development is considerable: the sound is produced by control of vocal cords in the larynx, as in man; it is variously increased by means of resonating sacs; the range of pitch is rather wide; any species can be identified by its calls or songs; in fact, for the Salientia themselves, their voice is a means of recognition and communication, and for man it is among the safest of characters on which to found species identity in this group of animals

THE AMERICAN TOAD SINGS

From the bank or from shallow water the American toad, *Bufo Americanus* Holbrook, sends forth its prolonged musical trill. When the call is given with full force, the pouch becomes nearly twice the size shown here and distinctly two-lobed because of pressure of air from the two openings which lead into it under the tongue; also, the call takes on a dual character as if it were a combination of a whistled high note and a droned low one. This toad song has a quality of sweetness perhaps unequaled in nature in the spring except by the song of the bluebird and the spring notes of the chickadee.

The American toad is not inured to the low temperatures endured by peeper, leopard frog, and wood frog. It follows them, emerging in early April, when the lowest maximum air temperatures are from 53 to 57 degrees Fahrenheit. It does not sing actively in chorus, however, until the temperature of the air is about 10 degrees higher than this. By the end of May, American toads wander away into the adjoining fields and gardens, even into city streets where they seek insects under the electric lights

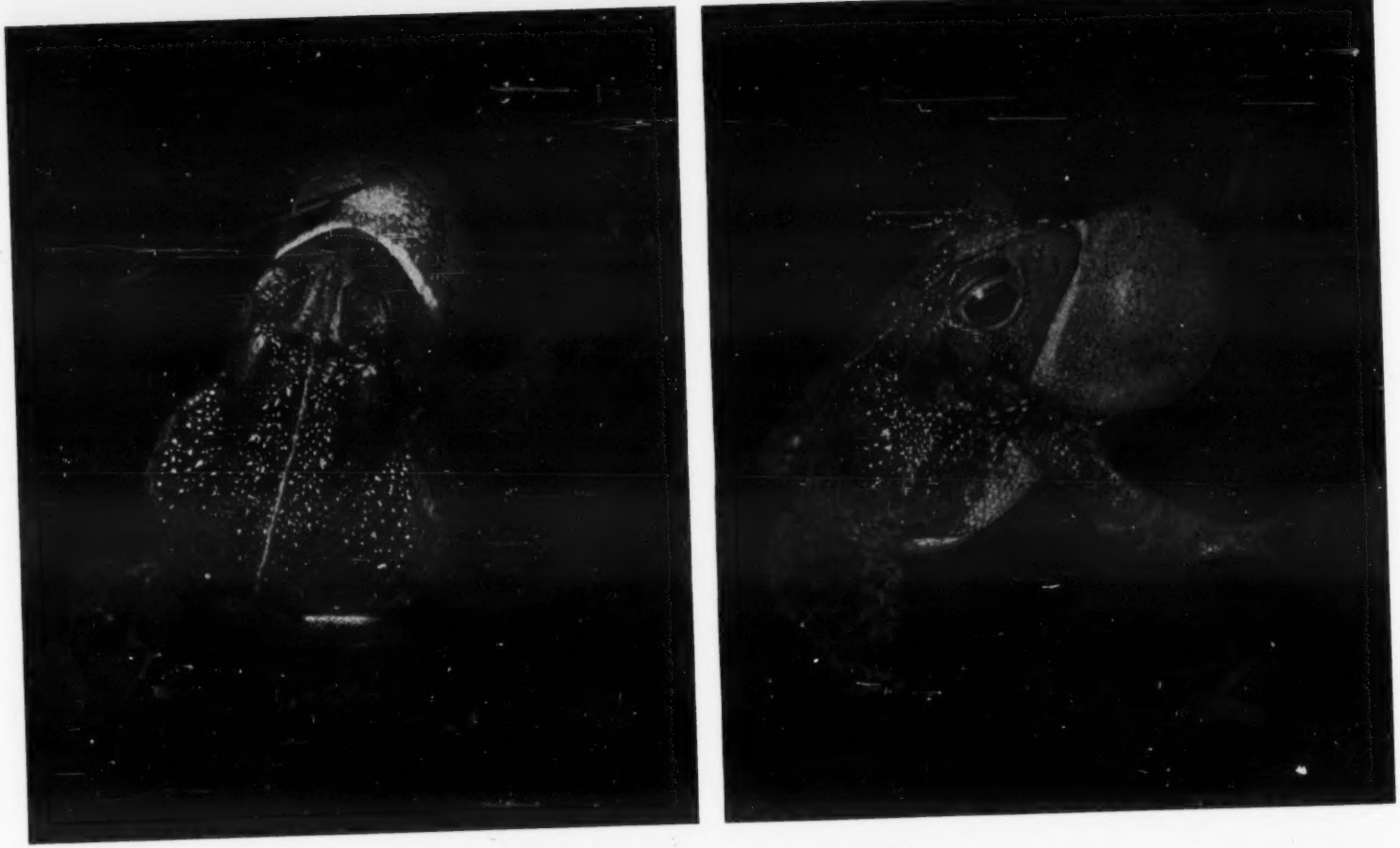


HIS SONG MAY SOUND LIKE AN INDIAN'S WAR WHOOP

Fowler's toad, *Bufo fowleri* Garman, appears in the ponds about two weeks later than the American toad and vigorously announces its presence by its loud cry. This is not trilled as is the call of the American toad, and is metallic in quality. It begins high in pitch but descends three or more intervals before its close. A few individuals are likely to remain in and about the ponds until midsummer, so that the call, reduced to a melancholy wail in comparison with its earlier vigor, may be heard after all other Salientian songs have ceased—except perhaps an occasional "jug-o-rum" of the bullfrog

FOWLER'S TOAD—IN THE SHALLOW WATER OF THE POND AT NIGHT

His eyes shine in the darkness, the pupil fully expanded to take all advantage of the night's weak illumination



STUDIES OF FOWLER'S TOAD "SINGING"

These photographs from life illustrate well that the toad's fear instinct is wholly in abeyance notwithstanding the proximity of camera, photographer, and flash light. These portraits are so sharply focused that they might well serve as detailed structure studies of the species. Fowler's toad can always be distinguished from the American toad, which for a large part of the range occupies the same territory, even being found in the same ponds, by the following comparative characters: Fowler's toad is likely to be smaller, grayer, and more slenderly built than the American toad; the parotoid glands at the shoulders are long and narrow with nearly parallel sides instead of kidney shaped; these parotoids are not connected with the bony cranial crests by a stemlike crest as in the American toad; the wartlike tubercles on the back are relatively small with several aggregated in each of the dark spots of the color pattern; the under surface is not conspicuously spotted, etc.

is not conspicuously spotted, etc.

MOST RARELY SEEN OF ALL THE FROGS AND TOADS OF EASTERN NORTH AMERICA

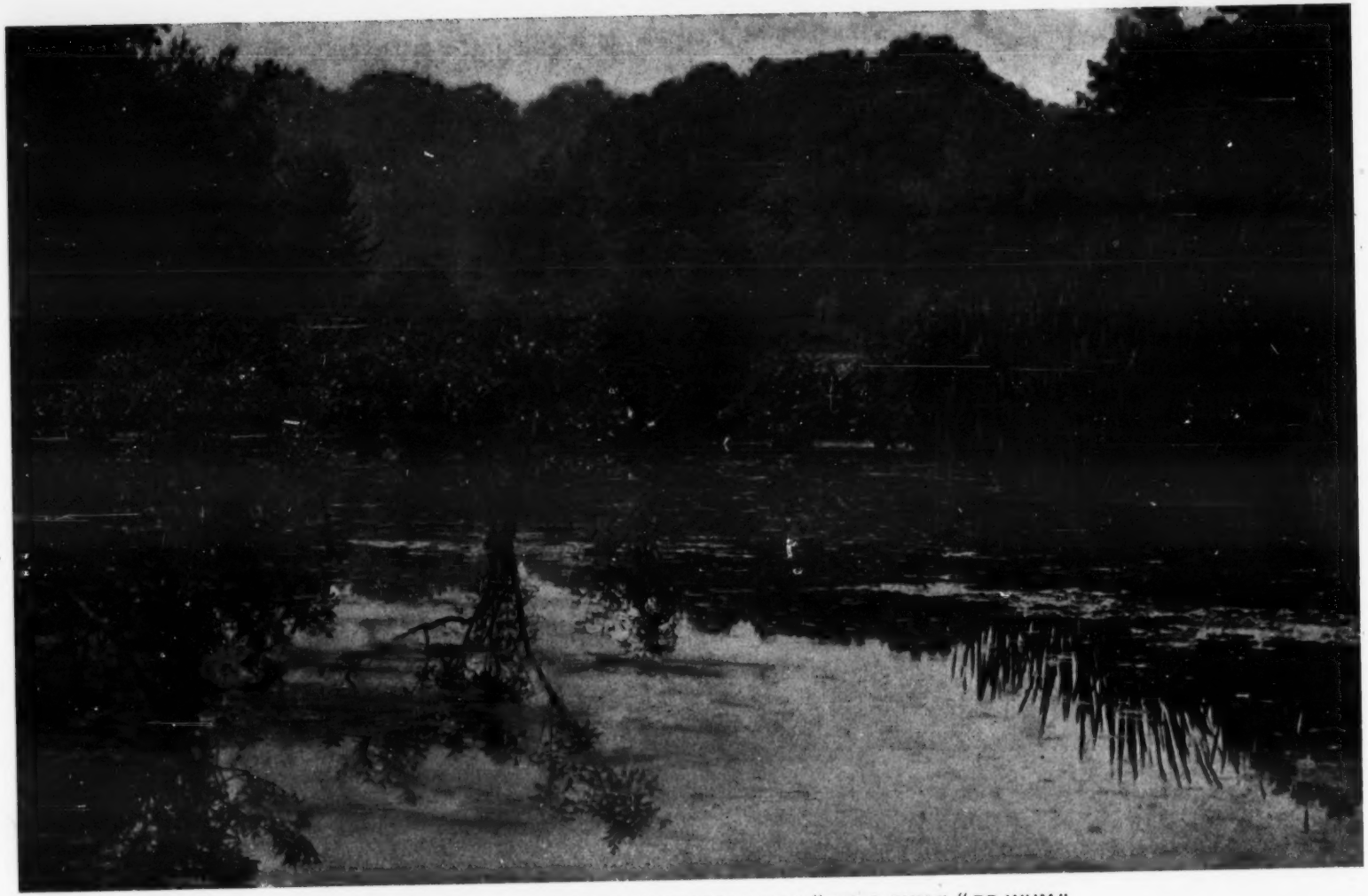
The spadefoot toad, *Scaphiopus holbrookii holbrookii* (Harlan), is so nocturnal and so secretively subterranean in its habits that even naturalists who are on the lookout for it may not see it for years at a time. It comes out from its burrow and seeks the neighboring pond some night after a hard warm rain at any time between April and September and returns to its burrow one or two days later. The spadefoot's voice is a noisy "ker-r-raw," like the frightened cry of a barnyard fowl caught at night. It often "sings" while sprawled out on the water and the distended vocal sac is like an enormous pearly white balloon which buoys up the creature's head. It may sing with its eyes closed, as illustrated in a large series of photographs similar to the above. Very few detailed observations have been made on the spadefoot and there is much yet to be learned about its habits and life history

A singing pickerel frog, *Rana palustris* Le Conte.—This species is unusually shy and wild and spends much time in hiding, thus differing from the leopard frog, which it rather closely resembles in color pattern. (It can always be distinguished by the squarish shape of the spots, and by the bright orange color on the under surface of the thighs, displayed when the frog makes a flying leap.) It differs fundamentally from the leopard frog in its reaction to temperature, agreeing more nearly with the American toad. It does not awaken from hibernation as do leopard and wood frogs and peeper, at about 41 degrees Fahrenheit, but continues torpid until the water registers from 45 to 53 and the average maximum air temperatures are from 58 to 67. Not until some time in April, usually early in the month, are we likely to hear its voice. The call is low pitched, irregularly vibrant, less prolonged than that of the wood frog, and of less carrying power. The vocal sacs, one at either side of the head, are small and covered with thick skin

The cricket frog, *Acris gryllus* (Le Conte), is an actively jumping creature, smaller even than the spring peeper (shown nearly twice natural size in the photograph). Its vocal performance combines a musical element of considerable carrying power and a rattle. It is given in three phases: a loud "clink, clink, clink . . . . " which changes to "click-e-ty, click-e-ty, click-e-ty . . . . " with the rhythm of the hoof beats of a galloping pony, and a trilled "cree, cree, cree . . . . " somewhat like the call of a true cricket. In a chorus by many frogs all these sounds are combined into a confusion like a rattling of pebbles when heard near at hand, and at a distance like the musical jangle of small sleigh bells. Cricket frogs appear in April and may be noisy during much of the month of May

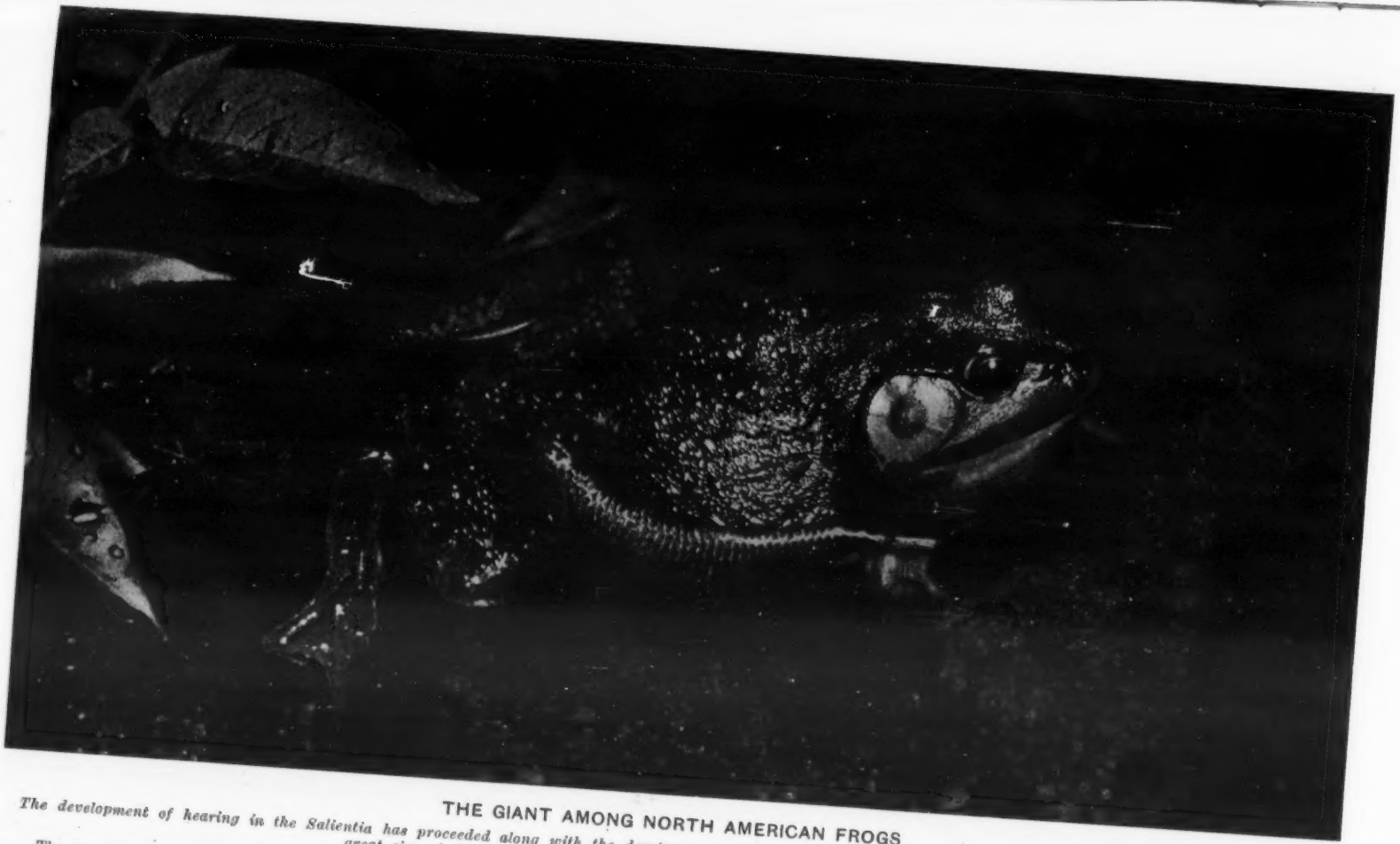
A sound like the "plung" from the plucked string of a base viol explodes from his yellow throat. This call is so very explosive in character and ends so abruptly that the photographer must snap the camera at the very beginning to get a picture of the distended throat. The green frog, *Rana clamitans* Latreille (about two thirds natural size in the photograph), may make his first spring appearance in April, less than a week after the pickerel frog, when the lowest maximum air temperatures are from 54 to 61 degrees and the water temperatures from 46 to 58. He does not join the spring choir, however, until the temperature is still higher, in May, about a month later. This species, when startled, leaps into the water with a high-pitched scream (a sound made possibly with the mouth open as in the case of the loud scream of the bullfrog). Tadpoles of the green frog do not change to the frog form until they are one year old

A famous "rain prophet"—the common "tree toad" or, more properly, tree frog, *Hyla versicolor versicolor* (Le Conte), wakens to activity at a much later date than any other frog or toad except the bullfrog. There is required an air temperature of about 58 degrees with average maximum temperatures of from 66 to 70 before it rouses from hibernation; therefore its voice is not often heard before some time in May just when the bird chorus is reaching a maximum. After this species leaves the pond in June, it lives on the trees of the woods or the orchards or on trees and vines about the house. It gives its loud, resonant trills frequently when the air is moist, even as late as October, and is silent during dry spells, and has thus gained its name of "rain prophet." The vocal pouch may be distended to great size and vibrates forcibly during the trilling



WHERE BELLOW THE SOUNDS "BE DROWNED," "JUG-O-RUM," "BR-WUM"

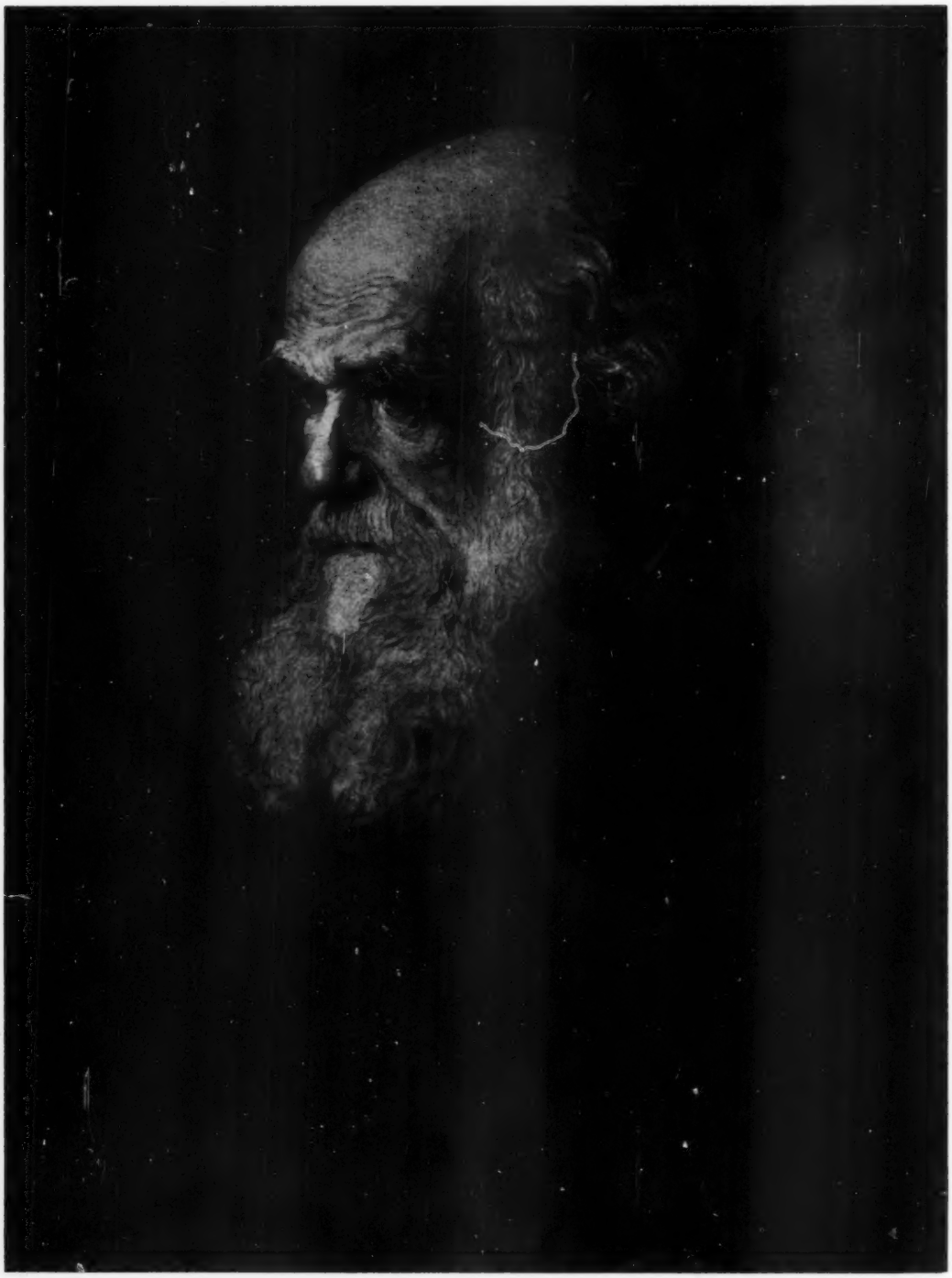
The bullfrog is our most aquatic species, not frequenting the shallow marsh and small pond with green and leopard frogs, but seeking out the deeper waters of river margin, lake, or pond. Bullfrogs probably never leave the water to seek a new haunt unless driven by some catastrophe. The tadpoles do not pass through the metamorphosis to the frog form until they are two years old



THE GIANT AMONG NORTH AMERICAN FROGS

The development of hearing in the Salientia has proceeded along with the development of voice. The bullfrog agrees with its near relative, the green frog, in the great size of the external "ear," the circular tympanic membrane behind the eye

The sonorous base notes of the bullfrog, *Rana catesbeiana* Shaw (photographed about one half natural size), are given with such intensity that the whole body of the frog vibrates and throws the water into minute waves. He is the last musician to enter the spring choir. He does not appear until late May, often the first of June, when water temperatures are from 57 to 69 degrees Fahrenheit and the lowest maximum air temperature is 68. We have four frogs in eastern North America which may be designated water frogs: the bullfrog and the green frog, the pickerel and the leopard. These hibernate under water and the time of their emergence thus depends on the temperature of the water rather than on the temperature of the air. Each species of the Salientia, toad or frog, of land or water habit, has its particular reaction to temperature and its especial time for emergence. Therefore under normal conditions the species would follow one another in a definite and unalterable order. Conditions, however, are not often normal. An early spring brings out the late forms prematurely together with the early, and a late spring delays the appearance of the early species so that they may appear simultaneously with those due later. Thus the spring choir is varied from year to year



THE AUTHOR OF DARWINISM

From a proof etching by G. Mercier, published in 1890, after the painting from life by W. Ouless, R.A., made in 1875

Darwinism came into existence about sixty years ago on the publication of *The Origin of Species*, in 1859 and its acceptance by a large part of the intellectual world. Darwinism is a method of evolution, not evolution itself—that had been recognized long before. Darwinism is an explanation of evolution through "natural selection" and the "survival of the fittest"; it gave for the first time a working hypothesis to the naturalist

Sixty Years of Darwinism

A LOOK BACKWARD AND FORWARD

Molluscan shells of the sea-beaches and ocean beds of the millions of years of the past suggest that evolution works gradually and continuously along definite controlled lines.—A field for future research

By AMADEUS W. GRABAU

Formerly Professor of Palæontology, Columbia University

SIXTY years ago Darwinism was born, after a period of gestation which had lasted about twenty years. The scientific world was divided in its opinion respecting the vitality of the infant,—the religious world was hostile to the newcomer, regarding him as a false messiah come to destroy, not to save, while the intellectuals who professed allegiance to neither camp were divided in their attitude,—some saw in his advent the promise of a new dispensation, others voiced their scorn of his pretensions in ridicule. Listen to the scoffers:

> "A deer with a neck full longer by half
> Than the rest of his family, try not to laugh,
> By stretching and stretching, became a giraffe.
> Which nobody can deny."

Now it happens that this has reference, not to Darwinism, but to a much older child of the naturalist Lamarck. This, however, the scoffers did not appreciate. The trouble with the average man was then, as it is now, that he confused Darwinism with evolution. To continue our metaphor: Evolution was not born but, like Topsy, "just grew." Aristotle knew about it, or thought he did, and other philosophers before and since his time have tacitly assumed its existence and speculated about its nature. Goethe, Buffon, Saint-Hilaire, Lamarck, and the grandfather of Charles Darwin talked and wrote about it, but of its real character they had, as a rule, only a hazy conception.

Darwinism Is a Method of Evolution

Darwinism is not evolution, it is a method of evolution. So is Lamarckism, and so is orthogenesis. Darwinism attempts to explain evolution, to find a natural cause for it,—evolution itself it takes for granted.

But while Darwin did not give to the world the idea of evolution, he was the first to marshal an overwhelming array of facts which clearly admitted of no other interpretation, and to present them to the intelligent in such a way that they could not honestly refuse to consider their philosophic import. Moreover, he was the first to offer to the working naturalist an explanation of the method of evolution, and to establish the existence of a law that by a process of natural selection those best adapted to their environment would alone survive.[1] As Huxley says, "up to the time of the appearance of Darwin's *Origin of Species*, . . . the evidence in favor of transmutation was wholly insufficient, and no suggestion respecting the causes of the transmutation assumed which had been made, was in any way adequate to explain the phenomena."

"The suggestion," Huxley goes on to say, "that new species may result from the selective action of the external con-

[1] It is of interest, however, that Darwin was not the only discoverer of the law that by natural selection the unfit are eliminated, and the fit preserved. Alfred Russel Wallace had independently discovered the same law, and both discoveries were announced to the scientific world at the same time. Herbert Spencer, too, before this, had appealed to the survival of the fittest as a means for progress in the organic world.

ditions upon the variations from their specific type which individuals present, and which we call 'spontaneous' because we are ignorant of their causation, is as wholly unknown to the historian of scientific ideas as it was to the biological specialist before 1858. But that suggestion is the central idea of the *Origin of Species* and contains the quintessence of Darwinism. . . . That which we were looking for and could not find was a hypothesis respecting the origin of known organic forms which assumed the operation of no causes but such as could be proved to be actually at work. We wanted, not to pin our faith to that or any other speculation, but to get hold of clear and definite conceptions which could be brought face to face with facts, and have their validity tested. The *Origin* provided us with the working hypothesis we sought. . . . "

What then is this quintessence of Darwinism, this doctrine of natural selection, which led to such a general acceptance of the theory of transmutation of species, by a considerable portion of the intellectual world?

The Weeding Out by the Environment Is Natural Selection

In the first place, we must disabuse our minds wholly of the very general notion that natural selection is an entity or a force that does something. Such figures of speech as "Natural selection weeds out the unfit," "Natural selection preserves the fittest," and others like these, are misleading. Natural selection is not a force, it is a process. The weeding out by natural means of the unfit *is* natural selection; the preservation of the fittest in the struggle for existence is their selection in nature for survival. What then, you ask, is the agent or force that does the selecting in nature? To this we answer: The environment, using that term in its most comprehensive sense. To illustrate: A boat filled with human beings capsizes. If each thinks of himself alone, those who can swim and are strong enough to reach the shore, will survive; those who cannot swim will drown; while those who can swim but are not strong enough to resist the shock and exposure, will also perish. Thus the ones adapted to at least temporary existence in that particular environment will survive. That is natural selection. If one of the men remembers that a beloved companion cannot swim, and saves that companion in preference to others, he performs an act of artificial selection. If the boat capsizes in the open ocean and no help is near, all must perish, for the adaptation is not sufficiently complete.

Another illustration: A caravan in a desert has a limited supply of water, sufficient to support only one half the number adequately until the next water hole is reached. The stronger or more cunning might seize the water and leave the rest of the caravan to perish. That would be natural selection. Being human, however, they all share the inadequate supply, and all perish, or reach the water hole in an enfeebled condition. Natural selection has been interfered with at the physical expense of the entire caravan. What is gained is beyond the forces operative in natural selection.

Again: Two deer are surprised by a hungry wolf. The more alert of the two and the swifter of foot escapes, the other is devoured. Natural selection has taken place on the basis of alertness and of swiftness of limb and foot. The fittest in these respects survives. The English sparrow drives out the native song birds. The sparrow is physically more fit to survive, but æsthetically it is a poorer type of bird. Thus the fittest is not always the best from another point of view.

In a state of nature, the strongest and most cunning, who can get the food supply, the ones best capable of resisting the attacking enemies, escaping

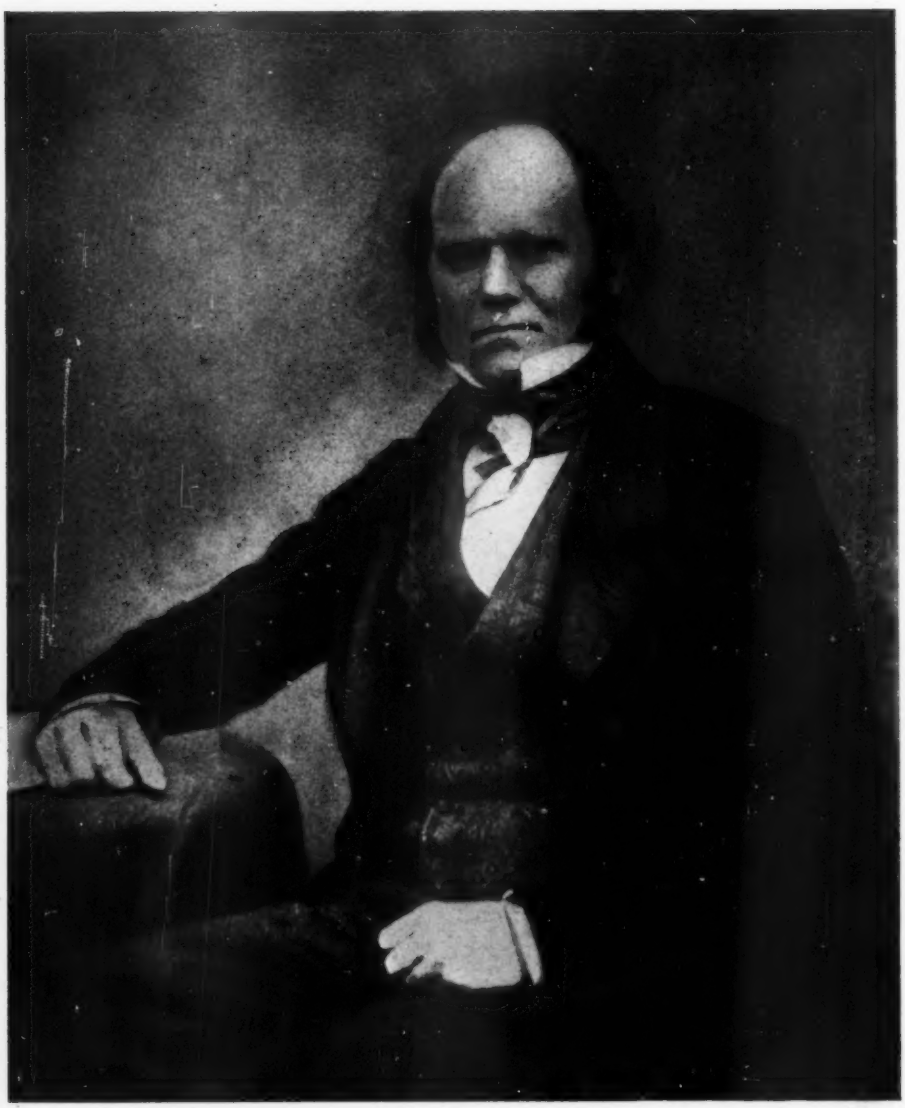
from them or eluding them by deception or otherwise, those immune from diseases which destroy the others, those capable of withstanding great changes of climate or nullifying their effects by periodic migration to milder regions, by burrowing in the ground, or otherwise, those capable of resisting drought by storing up water, as do the cacti among plants and the camels among animals,—in short, those that can withstand best all the destructive agencies in nature, and can gain their requisite supply of food, those are the fittest, and they will survive. Civilization, on the other hand, succors the weak, feeds the hungry, clothes the naked, and natural selection is not operative,—the physically unfit survive.

The Process of Natural Selection Works in Other Ways

Natural selection, however, takes place in other ways as well. What determines that of two women grinding at the mill, one shall be taken and the other left? The choosing of a mate in human society not infrequently depends on psychic rather than on physical qualities; on the beauty of the soul, rather than the beauty of the body, although physical characteristics, among which we may class the possession of wealth and the social standing it implies, form too often the basis of selection. Physical characters to a certain extent also form the basis for "sexual selection," as it is called, where this takes place among animals in a state of nature. Here, often, special characteristics, such as bright plumage or song among birds, various ornaments or accomplishments in other animals, —attributes regarded as attractive to the opposite sex,—are developed by the members of that sex which furnishes the candidates for selection. There is, however, good reason for the belief that many, if not most, of the characters commonly regarded as significant in sexual selection, are merely expressions of sexual maturity on the part of the more virile sex. Here, probably, belong the antlers of the stag, which, although used in fighting among the males at the mating season, can hardly be regarded as primarily developed in response to the fighting propensity, which is itself an expression of sexual virility. For, if so, how are we to account for the fact that the antlers become fighting weapons only when their growth is completed, and when the easily injured coating of "velvet" has served its function and is discarded; and how are we to account for the seasonal shedding of the antlers themselves, when the period of sexual excitement has passed?

Special characters of form and color are developed in the males of some fish, for example, which never mate with the females, but separately fertilize the eggs cast off by these. Among animals as among men, propinquity probably plays the largest rôle in influencing the choice of a mate, but it is no doubt true that the offspring may be powerfully affected by the greater vitality expressed at the height of sexual maturity of the parent, by the development of the brightest plumage, by the most complex and powerful antlers, by the most involved of dances or other antics among animals, or by the flashing eye, the heightened color, the daring deeds, the quickened intellect, and roused emotion which bursts into song or rhapsody in the human species. These characters are, however, the expressions of a condition rather than a means towards an end, although it is probably true that they may have an influence in bringing together physically and psychically attuned individuals, and so work for the betterment of the race.

It is otherwise when man consciously determines the mating of those subject to his control. Man breeds animals and plants for definite characters useful to him, or fancied by him, by se-

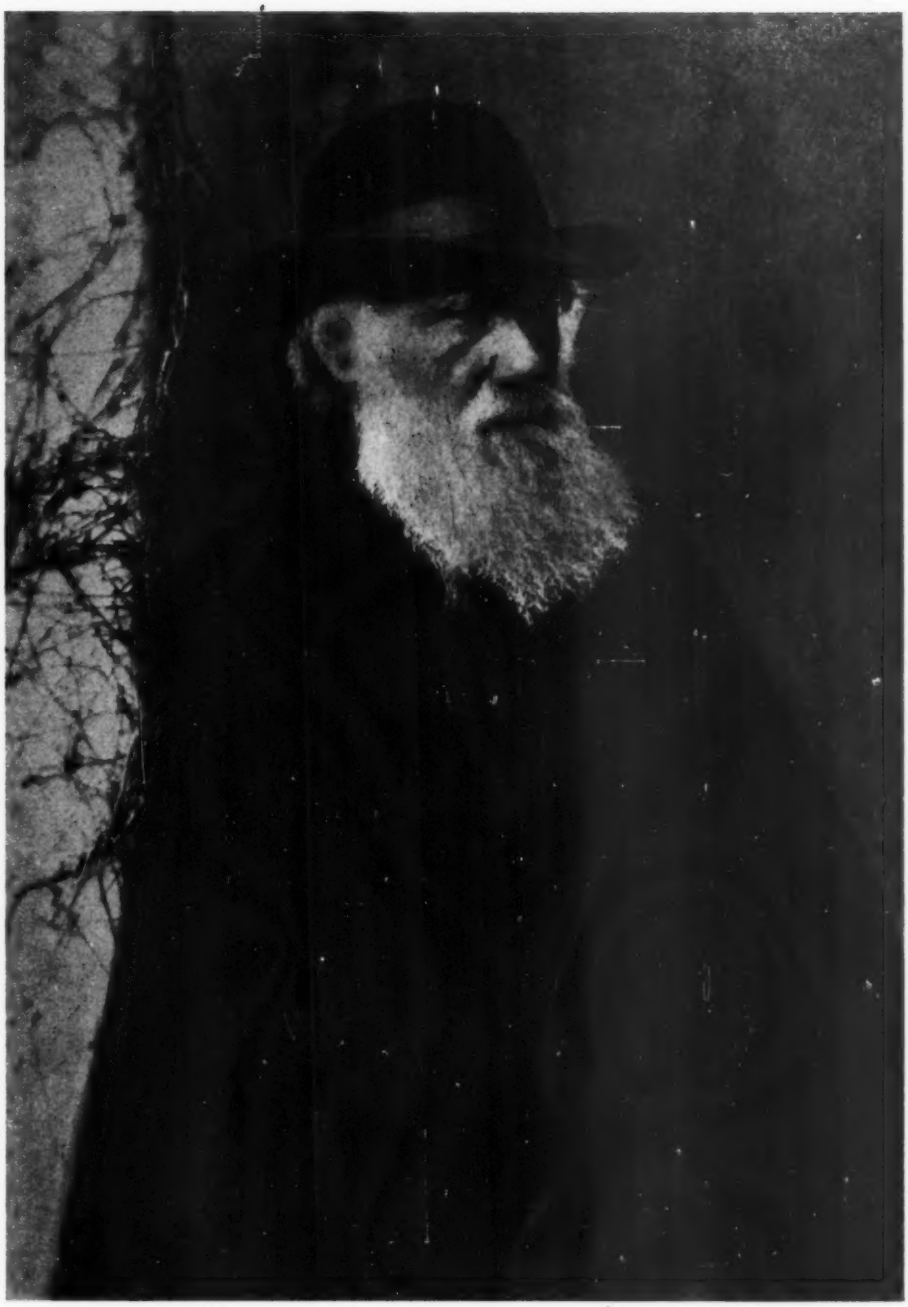


CHARLES DARWIN, PORTRAIT OF 1854

Photograph from life made by Maull and Fox, London, in 1854. Half tone from a print owned by the New York Academy of Sciences, from the restored negative

Darwin's observations and studies made him believe in the potency of the environment in giving direction to evolution. He observed that all creatures of a kind vary in minute ways from one another as their birthright, and he believed that where the variations were in harmony with the conditions of existence those animals naturally were preserved, to hand on by heredity the favorable variations.

The Darwinians of today (Neo-Darwinians, they have been called) are followers of Darwin who go farther than their master in saying that the organic world alone progresses by natural selection of such variations, minute and fortuitous (congenital but not controlled by any known law). There are many, however, who have questioned that these minute fluctuating variations have sufficient importance to be used by selection. Among these are the followers of De Vries (whose experimental work has been on plants), who believe in evolution by sudden jumps, by "mutation." Darwin at one time attached great importance to such sports, but finally relegated them to an inferior place



CHARLES DARWIN, PORTRAIT OF 1881

Half tone from a photograph from life, property of the New York Academy of Sciences, made by Elliot and Fry, London, in 1881

A man whose name and memory the world will honor to the end of historic time—for his industrious, laborious study, his clear reasoning, original thinking, and bold stand for scientific truth

lecting the parents with that end in view. This is termed artificial selection, and to it is due the wonderful variety of domestic races of animals and plants. It was, indeed, the study of artificial selection as practiced by the breeder that led Darwin to an appreciation of the selective process in nature, and, in the investigation of this obscure problem of ". . . the means of modification and co-adaptation," he invariably found "that our knowledge, imperfect though it be, of variation under domestication, affords the best and safest clue," and he begins his great book *The Origin of Species* with a chapter on "Variations under Domestication" and the principles of selection by man.

But it is not only with domestic animals and plants that man performs the selection of mates; he not infrequently does this for his own offspring as well. And here he too often follows principles that as a breeder of fine animals he would scorn. The orthodox Jew selects for his daughter a prosperous man of business when he cannot obtain a bridegroom learned in the law. The aristocratic rulers mate their children for political reasons, and the socially ambitious mother sells her daughter to the highest bidder, regardless of his physical, mental, or spiritual fitness. Fortunately for the race, the scheming parent in this last instance is sometimes thwarted by the spirited daughter, who makes her own selection on a higher plane, unmindful of immediate consequences. It is in the modern science of eugenics that the standard of selection is scrutinized, and that the process is elevated to the level which insures to the future the survival and perpetuation, with constant improvements, of the truly fittest.

Variation or Lack of Equality Is Preliminary to Natural Selection

Without much reflection on the matter it will be seen that selection can take place only if there is diversity of characteristics in the organisms from which selection is to be made. If all animals of a group were alike in every respect, if all men were truly equal, survival would be a matter of accident. Thus variation is a necessary preliminary to selection. But variation must be sufficient to have a selective value. A slight increase in the length and slenderness of the leg may insure sufficient agility to enable its possessor to outdistance his comrades and so escape from the pursuing enemy to which the others succumb. But how about an extra minute spot on the wing of a butterfly, or the union of two spots on the wing cover of a beetle? Will a hungry bird stop to count the spots or note their arrangement in selecting its prey? Evidently there are variations which have a selective value, and those which have none. To be sure, the extra color spot or the bar may be a character which appears only as companion feature of, or in correlation with, some other variation, such as greater power of evasion and the like, which is the real character that insures survival. Thus the slightly different insignia on the shoulders of an officer's uniform do not protect him from the enemy's bullet. As an officer, he is commanded to use greater caution and seek better protection. The shoulder insignia are merely a correlative variation of the variation in rank, between him and the private.

But, in the belief of many naturalists, minor variations are not always nor perhaps generally to be classed as correlative of others which have a selective value. That they exist admits of no doubt; indeed, it is on the basis of such minor variations that species are established. We may never agree on what amount of variation is necessary to produce a new species,—in fact, no two naturalists ever do agree wholly on this point; we may, indeed, be convinced that nature knows no species, only individuals, but we all agree that

variations do exist in nature, and that in fact no two individuals are ever exactly alike. Moreover, we recognize that most variations are congenital: that is, they are part of the endowment of the organism at birth, its birthright or birthcurse as the case may be. And we have further learned that characters which appear as the result of such variations may be handed on to posterity unto the third or fourth generation, or, if they subserve the divine command of nature, even unto the thousandth generation. Whether characters acquired during the lifetime of an individual may be transmitted to the offspring is still a mooted question, but with such characters we are not now concerned.

We are by no means in agreement, however, as to the nature of congenital variations; are they definite or indefinite, continuous or discontinuous, gradual or abrupt? Darwin believed in minute fluctuating variations about a mean, and that, by selection, those individuals which happened to vary in a favorable direction, that is, in a direction most in harmony with the environment, would be preserved, and so hand on the favorable variation. Further variation about this new mean, and continued selection for favorable characters, would in time produce the specialized and highly adapted types, the favored few, fit to survive out of a multitude doomed to extinction. This is the gospel of accident, the doctrine of fortuitousness, and it is the cardinal doctrine of the ultra-Darwinians, those followers of Darwin who, unlike their master, see in natural selection, on the basis of favorable but fortuitous variations, the sole means of progress in the organic world.

Theory of the Neo-Darwinians Based on Minute Fortuitous Variations

Darwinism then, in the sense of the modern followers of Darwin, the Neo-Darwinians as they have been called, is the doctrine, that the environment destroys the unfit and preserves the fit—natural selection takes place; that the essence of fitness is adaptation to the conditions of existence—the best adapted will survive and hand on to their offspring those characters which have made them fit; and finally, that these character arise as the result of fortuitous variation; that is, variation apparently uncontrolled by any known law.

But the environment, too, is constantly changing; the Garden of Eden becomes a desert, roses bloom on the site of a prehistoric Sahara. "There rolls the deep, where grew the tree. . . . There where the long street roars hath been the stillness of the central sea." Adaptations, which under one environment insured survival, under changed conditions spell death. The *Megatherium*, the last of a long line of ground sloths, and well adapted to the food of its native haunts, became enfeebled as this food supply diminished in consequence of a change in climate, and so fell an easy prey to its chief adversary, the saber-toothed tiger. The sabertooth, in turn, fitted with tooth and claw adapted to hunting and stabbing to death these slow-moving thick-skinned herbivores, faced starvation when the last *Megatherium* was devoured, because from over-specialization this cat had lost plasticity to adapt itself to the swifter-footed grazing animals which formed the prey of its more agile cousins, the true tigers, the lions, jaguars, and the other great biting cats which still survive where man, their principal enemy, permits it.

The struggle for existence denies opportunity to the unfit; always and everywhere the fittest alone survive, always and forever the weak go to the wall. That is Darwinism pure and simple. Hope lies in a changing environment,—the fit today become the unfit tomorrow. The law of the jungle cannot survive the jungle—the mili-

tarist cannot survive in a nonmilitaristic age—nor the Bolshevist the restoration of the reign of reason. When the environment of common sense is reestablished, the worker and the capitalist each again will find his place, and the advantage to all will be seen in the development of those qualities and powers which will make the unfit of today fit to fill their proper place in the united army of struggling humanity. That, too, is Darwinism.

Selective Value of Fortuitous Variations Questioned

But, I repeat, Darwinism is not the sole factor in evolution, at least not in the belief of many students of nature. To begin with, the value of fortuitous variations as a basis for selection is seriously questioned by many who cannot accept minute changes in form and character as of sufficient import to determine survival. Color harmony with the surrounding habitat may protect the animal by deceiving its enemy, the camouflaged ship has a chance to escape the lurking submarine, where the one not thus protected will be lost, but such adaptations are not small, they are large variations from the normal. A single stripe, the first step in the production of the protective design upon the vessel, will not serve the purpose of deceiving the enemy any more than a single green spot would serve a brown *Mantis* upon green grass, or the first step in the development of a pattern which makes the palatable butterfly resemble the distasteful one, deceive the hungry bird. But fortuitous variations are first steps, they are minute beginnings in the production of a serviceable whole and as such, cannot serve the purpose of the finished product. To have selective value the variation must be adequate; to become adequate it must either arise suddenly, or develop by cumulative additions in the proper directions without reference to immediate selectivity.

The attention of naturalists has of late years been directed to those larger and apparently sudden variations which are seen to arise occasionally in nature, and which are familiarly known as sports. The phenomenon is illustrated by the short-legged ram, which appeared suddenly in Massachusetts in 1791, and from which the race of ancon sheep, once prized because of their inability to jump fences, descended. Darwin at one time attached great value to such sports, but later on relegated them to a place of secondary rank.

Selection by Mutation

But when the Dutch botanist Hugo de Vries discovered sports of the evening primrose (*Œnothera lamarckiana*) in a field not far from Amsterdam, and found by experiment that these forms bred true to type, that is, they were not fluctuating, but had constant new characters, the attention of the scientific world was again directed to this phenomenon, and careful breeding experiments became the order of the day. De Vries and most of his followers became convinced that not by minute fluctuating variations about a mean, but by sudden jumps, was progress made. From causes still unknown, the elementary characteristics of an animal or a plant now and then undergo a sudden rearrangement, much as the colored glass particles in a kaleidoscope are suddenly rearranged to form a new pattern, and this new organic pattern constitutes a new elementary species. Such an abrupt rearrangement of characters De Vries called mutation, others have called it saltation, and it is generally thought of as a process uncontrolled by any known law. To the De Vriesians the new elementary species thus produced are the only variations from the type which count. They alone are subject to natural selection; they alone mark the steps in the progress of the organic world.

Study of Young Stages and Palæontology Suggest that Variations are not Fortuitous but Controlled by Law

The Darwinian and the follower of De Vries have a common starting point—they both concern themselves with adult individuals. The voice of the elder Agassiz, crying in the biological wilderness of the early half of the last century, and exhorting naturalists to pay attention to the immature stages of animals and plants—those stages which lie between the embryo and the adult—has never reached their ears, or if they heard, they did not heed. But a disciple who followed the master in his wanderings through the underworld, where dead and forgotten generations of animal life had written their own epitaphs on tablets of stone, listened and learned and, by patient search among the ancient life records, became convinced that the new faith into which he had been baptized, pointed the true way to biological salvation. Alpheus Hyatt proved what Agassiz preached, that the immature stages of an animal's life history furnish the key to its racial history, that the young animal repeats the adult characters of its ancestor which lived in the immediately preceding geological period, and that this ancestor in turn had repeated in its own youthful stages the characteristics of a still earlier member of the tribe. Agassiz did not accept the doctrine of evolution, but Hyatt recognized the philosophic bearing of the facts uncovered by his researches. Step by step, the history of each individual type carried him backward in the history of the race until the beginning was reached. Down the long corridor of time he passed and took his pupils with him. Eagerly each new inscription was scanned, and each pupil selected that which to him seemed most promising, and then began to unwind the long record of ancestral achievement. And whenever the way seemed long, and their courage began to fail, new vistas would open, and the pursuit regain new vigor. And in this quest it became increasingly more apparent that variation was not fortuitous nor indefinite, but controlled along definite directions. To be sure, the controlling force has not been revealed, or but dimly so, but the very definiteness of the variation leaves no doubt as to the existence of such a control.

The study of child life and of adolescence has a fascination all its own, but its value as a guide to human evolution is only beginning to be appreciated. We are of necessity compelled to study and compare separate individuals in different stages of their development, but we ought to study single individuals in all their stages from birth to adulthood or to death. In this manner alone could we eliminate the variations due to acceleration or retardation in development which obscure the record. Moreover, the records furnished by one generation must be compared with those of preceding as well as succeeding generations to determine the trend of development of that particular genetic series. Are such studies possible? If you photograph, measure, and carefully describe the characteristics of your child, year after year, from birth to old age, and if this child performs the same herculean task for its own offspring, and this is carried on in the succeeding generations for a thousand years, a mass of data of incalculable value to the student of human evolution would result. But neither you nor I would have the patience to carry through our part of this undertaking, or if we have, our children, or our children's children would most certainly fail to continue the work, even though we could convince them of its value. But if such records were automatically kept, generation after generation, and preserved for comparison,

LOUIS AGASSIZ, 1847

He had a passion for knowing living things, and was indefatigable in his collecting and study. In this connection he wrote his father, "I feel within myself the strength of a whole generation." As was said in memorial words on Agassiz[1], in 1896, life has come kindlier to all naturalists since Agassiz lived, because he bore that name. People thought natural history must indeed be a godlike pursuit if such a man as he could so adore it

the future would hold promise that we might master the secrets of existence from these records of the past, and find the key to the solution of the problem of human life and the control of human destinies.

Is this a hopeless dream? Not altogether, I believe, for although such records will never be made for man, nor even, in completeness, for any group of organisms, they do exist and have been kept for millions of years, with reference to certain characters, in untold generations, among the lower, simpler forms of life.

Record of Mollusk Shells through Millions of Years Suggests Evolution by Orthogenesis

The shell-bearing Mollusca, the lime-secreting coral polyps, and some other lowly forms of animal life have kept this record from the dawn of their existence, and although it refers only to bodily form and proportion, it is adequate to reveal to the close student at least some of the fundamental laws which control the development of all life. No one not a palæontologist or searcher in the ancient life-records of the earth can appreciate the wonders of the empty shell which the careless stroller on the sea-beach regards with idle curiosity. Only the palæontologist can wander along the sea-beaches of the past and gather the shells of long vanished oceans, and only he can read the record embodied in the form and structure of these shells and glimpse its meaning in terms of universal law. We need a thousand students of fossil shells where today we have but a score—we

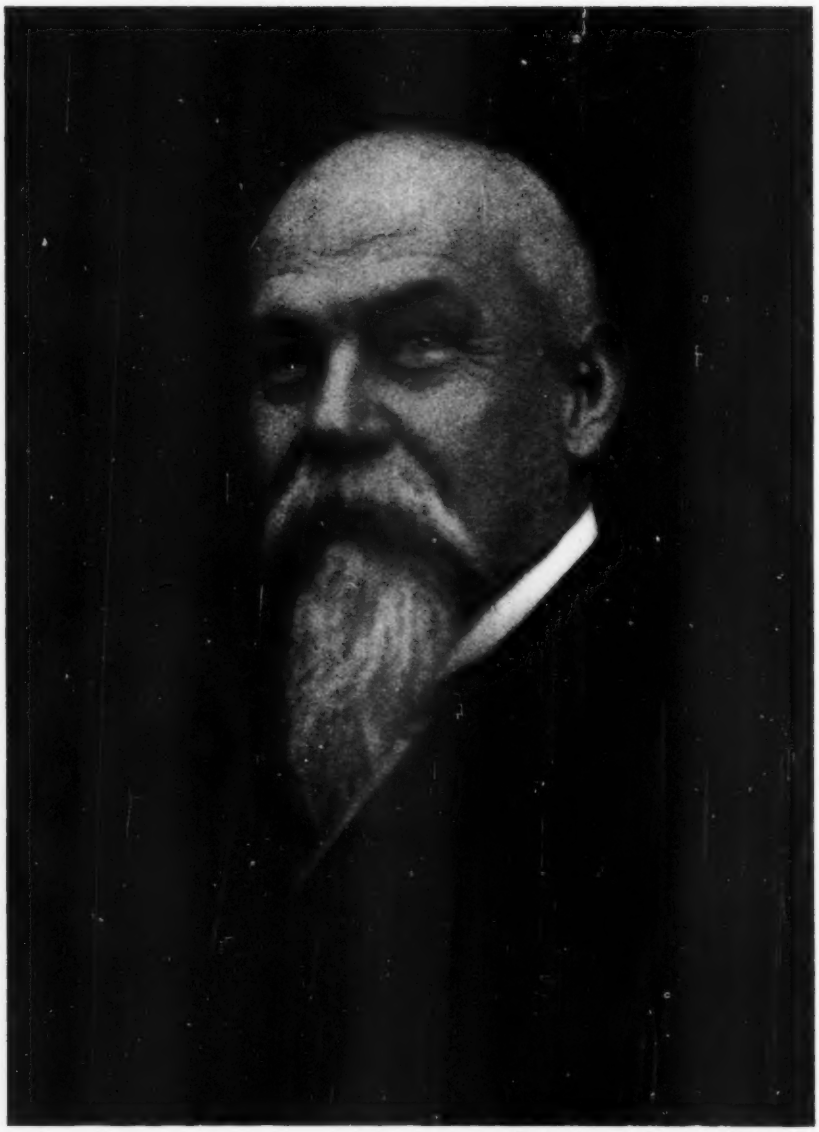
[1] "Louis Agassiz": Words spoken by Professor William James, at the reception of the American Society of Naturalists, by the President and Fellows of Harvard College, at Cambridge, December 30, 1896. *Annual Report*, Museum of Comparative Zoölogy, Harvard College, 1896-97.

LOUIS AGASSIZ, 1865

This and the portrait on the opposite page are accepted as authentic photographs, having received the approval of the family of Agassiz when they were published, on the centennial of his birth

The observations and theories of Darwin were based on adult animals. Agassiz exhorted biologists to study the immature stages of animals. He himself did not accept the doctrine of evolution, so that it was left for his students and followers to interpret the facts brought to light in such study and relate them with the new theories of the century.

Louis Agassiz's name cannot be mentioned in America without recalling his beneficial influence on the pedagogical methods then in vogue in the country. He gave a tremendous shock to the old method of committing to memory page upon page of printed facts which should be gained by observation or by reasoning. "Go to nature; take the facts into your own hands; look and see for yourself! Study nature, not books!"—such Agassiz maxims have been familiar to all laboratory students in America since his time



Portrait used through the courtesy of Mrs. A. G. Mayor

ALPHEUS HYATT, 1838-1902

Alpheus Hyatt was a student of Louis Agassiz. Under Agassiz's influence he was the first to undertake the detailed study of the post-embryonic stages in the life of the individual, chiefly in *Ammonites*. He compared these with the adults of preceding types. his first paper along this line appearing in 1866, and proved what Agassiz preached, that the immature stages of an animal's life history furnish the key to its racial history in the immediately preceding geological period. He and his students through a long pursuit of detailed palæontological studies came to a more and more decided conclusion that variation is not accidental or indefinite, but controlled along definite directions. We who work in this field today consider ourselves members of the "Hyatt School of Palæontology," a designation proposed by Dr. R. T. Jackson (formerly of Harvard), president of the Palæontological Society in 1919.

Alpheus Hyatt was at one time professor of palæontology and zoölogy in the Massachusetts Institute of Technology. He was curator of the Boston Society of Natural History Museum and curator in the Museum of Comparative Zoölogy, at Harvard College, until his death in 1902

need men and women who by careful search of the life-record of the past will lay the foundation for the superstructure of the future. The humble mollusk must become the teacher of the minister and the philosopher, of the lawmaker and the reformer; these must go to it, to learn first principles because, as keeper of the record, it guards the history of the past. You who read this, if you are new to the thought, may hold me extravagant, but I will undertake to convince you, if you will become a faithful student of molluscan shells and are not incapacitated by rigid adherence to received ideas. Leave Darwin for a while, become a follower of Hyatt, and you will return to Darwin with a truer conception of the real significance of his work.

The mollusk begins shell-building very early in life. The shell is not a mere protective covering, but an accurate replica in stone of the outline and minutest detail of form of the fleshy integument of the animal's body, a part of the animal which, like all others, undergoes progressive development. As this integument (the mantle) increases in complexity with growth, the shell records the change, records it step by step by adding the new features to the old, which are not destroyed but remain as a permanent part of the whole. Each step in development is faithfully recorded, until death puts an end to the process. But the shell is stone, its form is subject to no important changes in the course of time, barring accident, and, from the nature of the molluscan habitat, the shell survives the lifetime of its builder and becomes embedded in the sediment of the sea bottom upon which the next generation passes its existence. Successive layers thus accumulate, each with the permanent record of the life of its time inscribed upon it, and all arranged in chronologic order, the oldest below, the youngest on top.

Reading the life history of a single individual from the characteristics of the shell, we discover that the changes there recorded are not fortuitous but orderly, not in all directions but along definite lines; not by leaps but by minute gradations, each a little farther in the same direction. Comparing a thousand individuals of the same species from the same layer, we note that all undergo a similar development, all proceed, as it were, in the same general direction from a common starting point, but some go faster, others more slowly. Acceleration or retardation modifies the rate of progress, but does not affect its direction. As the number of shell-characters increases certain members of the group place the developmental emphasis upon one, others upon another character, and so divergence takes place. But each group, having begun to develop in a given direction, continues along that line with slow and progressive amplification of characters, at first minute and scarcely noticeable, but, when adulthood is reached, such characters may have become pronounced and form a basis for varietal distinction. Viewed as adults, such accelerated forms may appear to represent a kaleidoscopic rearrangement of parts, but seen by the light of the individual life history, the development is an orderly one. It is possible that when some of the examples of abrupt mutations of the De Vriesians are examined from this point of view, they may after all reveal themselves as normal types, except for certain features upon which development was concentrated to the retardation or exclusion of others.

Orderly progressive development by gradual and essentially continuous modification in definite directions is the rule in individual development, and prolonged study of the shells of successive geological periods has shown it to be the rule in racial development as well. Having started to develop in a given direction, from whatever cause,

the organism continues along that line, until features are produced which can serve as a basis for selection. If the results of definite development are violently out of harmony with the environment, if by persistent evolution in a given direction the permitted bounds are exceeded, extinction must result, eliminative selection takes place. Thus the progressive development of militarism has at last exceeded the restricted boundaries set by a changing age, and so become its own destroyer. So fashions in dress and ornament progress along definite lines until in some directions the changing limits of toleration are exceeded and extinction results; selection takes place.

This progressive modification in definite directions without reference to the end results was considered by Shaler and by Hyatt as a manifestation of what they called the "Inertia of Evolution." Theodore Eimer, the Tübingen zoölogist, and one of the few of that profession who made a serious study of the existing animal life in terms of individual development, adopted the name "orthogenesis" for the principle of definitely directed development by minute continuous modifications in a few directions. But his work never led him to the study of the historic record furnished in palæontology, and so, although the credit of formulating the theory is his, its demonstration devolved on Hyatt who independently developed it although he never used the term orthogenesis.

Variation is definite; it is progressive in determinable directions; it proceeds by minute changes which themselves have no selective value, but which, because of their continuity and cumulativeness, produce those features which are either useful or harmful in the struggle for existence. Selection is not a primary but a secondary factor in evolution, progress is controlled not determined by it. That is the lesson taught by the molluscan shell.

What makes for orthogenesis? What determines variation in one and not in another direction? There are those who, like Eimer, credit the environment with this function. Hyatt was not one of them; to him, as to many of us, environment is a stimulus, not a creator. Unless the possibility of development in a certain direction is there, environment is powerless. It may determine which of several directions the organism shall follow in its evolution, but the potentiality of such evolution must be preëxisting.

The environment of the galley developed Jean Valjean into a brute, that created by M. Bienvenue made him almost a saint. Palæontology has demonstrated the existence of orthogenetic tendencies in nature, the newer Darwinism must take account of these, and apply selection to environment. The law of the survival of the fittest can never be repealed, for nature's laws are immutable. The selection of the fit environment, however, lessens the scope of its activity, by directing evolution into channels which will lead to such degree of fitness as the nature of the individual makes him capable of. Neither environment nor selection will ever produce a silk purse from a sow's ear, but under the stimulus of the right environment even the ear of the sow will develop its highest capabilities, limited though these may be.

Flying Reptiles

By W. D. MATTHEW

Department of Vertebrate Palæontology, American Museum of Natural History

The American Museum has placed on exhibition a fine skeleton of the *Pteranodon* or giant flying reptile from the chalk formation of western Kansas. It is on the fourth floor, on the west wall of the corridor diagonally opposite the elevator, and is placed between two other fine fossil specimens from the same formation, the great marine lizard, *Tylosaurus*, below, a giant fish, *Portheus*, above. The skeleton lacks the outer end of the right wing, the sternum, one hind leg, and some of the neck vertebræ, and of the skull only two fragments are preserved. The form of the missing parts is known from other specimens in this Museum and elsewhere, and these parts have been painted on the background in a color nearly as dark as the original bone. The supposed outlines of the wing membranes have been added in a lighter tint.

THE skeleton of the new giant flying reptile[1] at the American Museum, while not the largest of its kind, is of quite impressive dimensions. The wings, if stretched out in a straight line, would measure 21 feet from tip to tip; in their present curve, about their actual position in flight, they measure 16 feet between the tips. Nothing of the wing membranes was preserved in this skeleton; but in other kinds of pterodactyls they have been preserved more or less complete, so that it is known that they were thin delicate membranes like the wings of bats. The bat's wing, however, is extended upon four out of the five fingers stretched out like the ribs of an umbrella. In the pterodactyl only one finger is elongated for a wing, the membrane being stretched between that and the rather long hind legs. The wing finger was the fourth digit, and the remains of the first three digits, reduced to small claws, can easily be recognized on the upper border of the wing. The claws were probably used by the animal to hang itself up to trees or rocks when at rest, much in the same way as bats do with their hind feet.

The head is a most extraordinary part of the animal. All pterodactyls have large but lightly constructed skulls with a long beak, which in most of them is set with sharp needle-like teeth. The *Pteranodon*, as its name indicates,[2] is toothless, with a great, sharp-pointed beak somewhat like that of a stork or a kingfisher, and a very light and delicately constructed skull with an enormous compressed crest stretching backward from it, almost equal to the beak in length. It is supposed that this great crest served to balance the weight of air pressure on the beak when flying, and enable the head to be held to the wind without danger of being forced sideways by a sudden gust or a turn in direction.

The neck is moderately long and strong, as would be needed to carry the large head, but the body looks absurdly short and small and the tail is a mere little stub. The backbone between the shoulders is all consolidated into a single piece (called the notarium), just as the backbone between the hip bones is consolidated in most animals into a single piece called the sacrum. The upper end of the shoulder girdle (scapula) is socketed into the side of the notarium, the lower end (coracoid) into the sternum on the under side of the body. This affords a very strong

[1] A notice of this specimen was published in the AMERICAN MUSEUM JOURNAL for April, 1916, at the time the skeleton was purchased from the finder, Handel T. Martin.

[2] It is from *Pter-(osaurian)*, a winged lizard or pterodactyl; and the Greek *an*, without; *odon(tes)*, teeth.

purchase for the wings, stronger even than in birds, which sometimes have the vertebræ partly consolidated like a notarium, but never get so far as to have the scapula socketed into it. Nor do the smaller and more primitive pterodactyls have the shoulder blade socketed in this way, although some of them have a notarium. Of course the wing bones of a bird are not extended out so far as those of a pterodactyl, a good part of the length of a bird's wing being made by the feathers.

The breastbone or sternum is not so unlike the breastbone of a bird. It is a broad flat plate with a high crest projecting forward and downward in the middle line, to which the principal wing muscle is attached. In this specimen, unfortunately, the sternum was missing altogether.

The ribs are very imperfect, short, and little curved. Probably a considerable part of the body basket was cartilaginous, so that it has not been preserved as a fossil. The ribs in this specimen were scattered, and no attempt has been made to bring them back to their proper articulations. They have merely been placed near to their proper location.

The extent and limits of the wing membranes as shown on the specimen are theoretical. No pterodactyl of this group has been found in which they are preserved. They have been found, indeed, more or less perfectly preserved, in some of the smaller species from the Solenhofen slate of Bavaria, notably the long-tailed *Rhamphorhynchus* and the short-tailed *Pterodactylus, Scaphognathus,* etc. But these more ancient kinds of flying reptiles are much smaller and more primitive, and so different from the great *Pteranodon* in the proportions of skull and other parts that they may have been very different in the wings as well. The best evidence for reconstructing the wings is the form and proportion of the bones and the probable purposes to which they could be applied. It is difficult to see how a sufficient width could be obtained for the stretched membrane of the wings unless it were extended down along the sides of the hind legs, as Dr. Williston believed, and not merely along the side of the body, as Dr. Seeley supposed. Then if the membrane was stretched on the outer side of each hind leg, it must also have been stretched between them and up to the tail, in order to take the strain off the legs. It may also be supposed that the membrane stretched from the neck out on each side over the shoulders as far as the "pteroid bone," as this would have some obvious mechanical advantages.

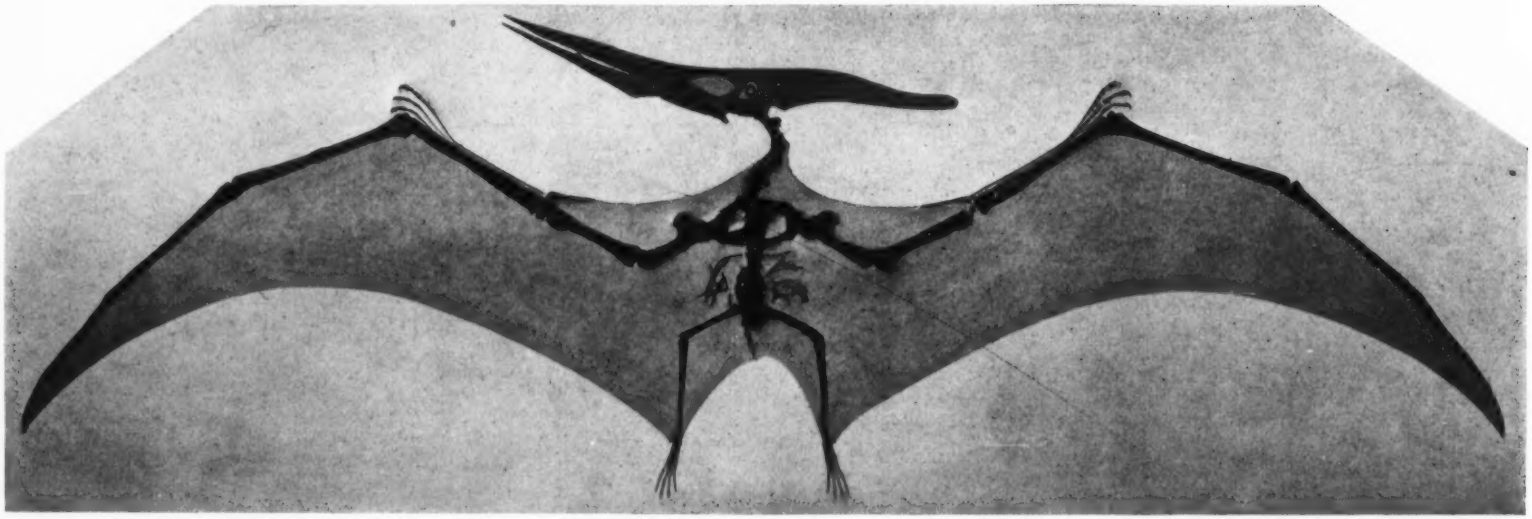
Resemblances of Flying Reptiles to Birds

In life all the principal bones of pterodactyls were thin, hollow cylinders of an exceptionally hard and flaky quality of bone. Moreover, there are, in some of the bones at least, openings corresponding to those in birds, which serve to allow air to circulate within the hollow cavity of the bone.

This is not the only point in which pterodactyls resemble birds. They have also a much higher type of brain than ordinary reptiles, the cerebellum or hind-brain is large, and, as in birds, the optic lobes are widely separated. It is also probable, in the opinion of some high authorities, that—like birds—they had a rapid circulation of the blood and continuously high body temperature, and were far above the reptilian stage in this respect. Indeed the high type of brain and the active life of a flying animal could hardly be maintained save through a high type of circulation such as mammals and especially birds possess.

Pterodactyls Are Reptiles nevertheless

But why call them reptiles? Why are they not a featherless bird or a



SKELETON OF GIANT FLYING REPTILE, PTERANODON

As mounted on the fourth floor of the American Museum

This specimen was found in the Cretaceous chalk of western Kansas by Mr. H. T. Martin in 1916, and is sixteen feet from tip to tip of the wings as mounted. The bones are very thin and fragile, and it is thought that the animal did not weigh in life more than twenty-five pounds.

The missing parts are painted on the background, and the supposed outlines of the wings restored in a lighter tint. Most of the skull, part of one wing, and one of the hind legs were missing; the ribs were scattered and incomplete, but it was not practicable to re-set them or restore their missing parts

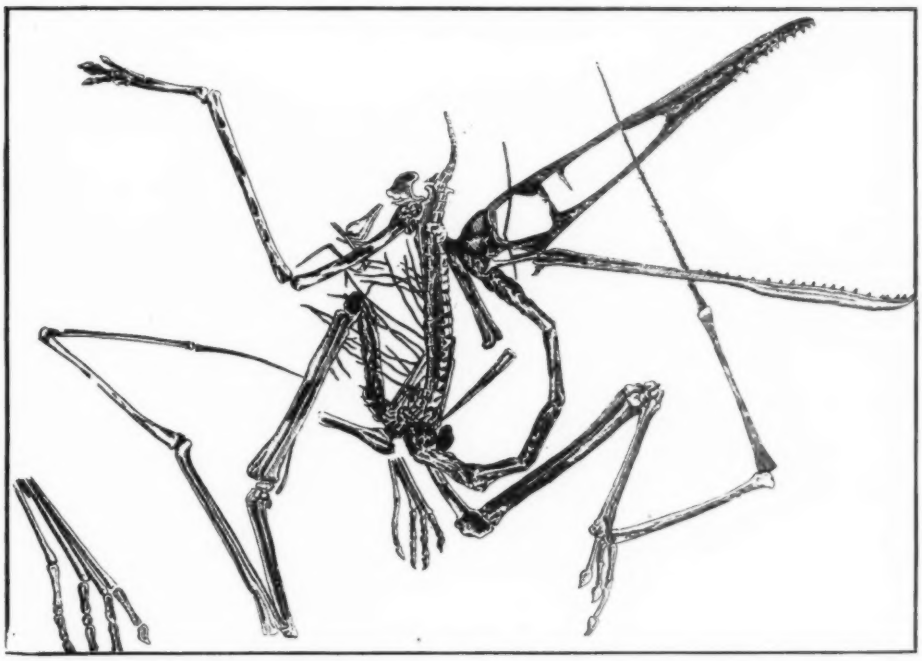
hairless bat, since they must admittedly have been more like these higher types of animals than like the lowly reptile in the most important aspects of their life and habits? The answer to that turns really upon theories of relationship and evolution of the different races of animals—theories, however, that are so universally accepted and almost unconsciously used that they might better be called principles.

Deliberately or unconsciously we have always adjusted or allocated an individual or a race by its affinities, not by its occupation. A "flitter-mouse" (bat) is not a bird, however much like a bird it may look and however little like its terrestrial cousins. A seal or a porpoise is no longer a "fish" the moment you recognize its closer kinship to the terrestrial mammals, although it looks much like a fish and is very different from the four-legged beasts of the land. Classification is all a matter of kinship, of relationship, and always has been, no matter whether you declare your belief in "Darwinism" or oppose it as violently as you please.

So then with our pterodactyls. They are not birds nor bats, but flying reptiles, because, in spite of their resemblance in habits to the birds and bats, and of the resemblance in proportions and in many adaptive characters that this has brought about, they are not at all related to the birds, but are descended from one group of primitive reptiles, while the birds are (more remotely) descended from another group. They form, indeed, a group apart from all other reptiles, but not so far apart that we strain the facts if we call them flying reptiles. The proof of all this, the evidence of relationship, lies in the comparison of the bones in pterodactyls, in birds, and in the various kinds of reptiles, especially in such parts and points of construction as are least altered or obscured by the changes that have fitted each race to its particular habits of life. There are innumerable points of detail to be compared in this way. Here it is possible only to suggest a few of the broader points in the skeleton construction that bear on its relationship.

First as to the wings: they are modified fore limbs, as in other vertebrates. The wings of insects are different, arising from the back and having nothing to do with the limbs. But whenever a vertebrate forms a wing or flying membrane of any sort it supports it on its limbs. Mythical flying vertebrates—dragons, winged bulls and lions, fairies—and angels—would appear to form an exception to this rule; their wings also grow out of the back, like those of insects, independent of the limbs. In real vertebrates, however, such membranes are always stretched either by the fore and hind limbs or by the fore limbs alone. And in the three groups of vertebrates in which this flying membrane has become so far developed as to make them capable of genuine sustained flight, namely, the birds, the bats, and the pterodactyls, the fore limbs are extended and specialized to an extreme degree to carry the greatly extended wing. But the necessary result is attained in the three groups by three distinct methods.

(1) In the bird the fore-limb bones are greatly elongated, and, with the first three digits stretched out side by side and quite solidly united together, carry the long wing feathers which extend and outline the form of the wing itself. (2) In the bat there are no feathers, but a thin membrane which is stretched out umbrella-fashion on four long slender digits, the second, third, fourth and fifth. (3) In the pterodactyl, as in the bat, there is a thin smooth membrane, but it is stretched upon the fourth digit only, the first, second and third digits being reduced to small claws which lie on the upper border of the wing.



This specimen, the first discovered pterodactyl skeleton, was described by Collini in 1784 among the curios of the Elector Palatine at Mannheim, Germany. It was recognized by Cuvier as the remains of a flying reptile. It is quite a small animal. The gigantic *Pteranodon* was not discovered until 1870

This skeleton of the long-tailed pterodactyl, *Rhamphorhynchus*, shows the thin leathery wings of these flying reptiles. This rare specimen is one of the treasures of the Peabody Museum of Yale University. It was found in the lithographic limestone quarries of Bavaria. *(After Marsh)*

The bat, when at rest, hangs upside down by the claws of the hind feet. The pterodactyl apparently hung right side up by the claws of the fore feet. The bird, instead of hanging, perches upright on a branch or on the ground.

The bird and the pterodactyl both share the reptilian character of the articulation of the lower jaw with a separate quadrate bone, not directly with the solid skull. In the bat, as in all other mammals, the lower jaw articulates directly with the skull.

Bats, like all mammals, have three joints on each finger except the first—and this is true of the greatly elongated wing fingers as well as of the toes of the hind feet. Birds, like the group of reptiles to which they are related, have a regularly increasing number of joints in the hind-foot toes (2, 3, 4, 5) but the wing fingers are too much reduced to show this any more. In the pterodactyls, derived from a group of reptiles with the same "formula" of joints in the toes, the fore claw shows 2, 3, 4, and the great wing finger also 4, its claw being lost; so that it evidently is derived from a series 2, 3, 4, 5. No trace is left of the fifth digit, which should have 3 joints. In the hind foot the series is 2, 3, 4, 5, just as in primitive reptiles.

These are a few points outstanding from numerous details in the construction of the skeleton, whereby the pterodactyls can be compared with birds, with mammals, and with reptiles.

Early Discoveries of Pterodactyls

Pterodactyls have been known for more than a century. The earliest published notice of the fossil skeleton was in 1784, by Collini, who was curator of the private museum of curios belonging to the Elector Palatine. Collini had no notion, however, that the skeleton had belonged to a flying reptile; he observed that it was clearly not a bird nor a bat; it might perhaps, he thought, be some kind of amphibian, but he concluded that it was probably the skeleton of some marine animal. It was recognized by Cuvier in 1801 as being a flying reptile. Other learned scientists of the time insisted that it was a bat, or a bird, or a flying fish. Cuvier's description and discussion of the animal in his *Ossemens Fossiles* is a masterpiece of sound scientific argument which, although it did not convince all of his contemporaries, has settled the question for his successors. Many specimens, mostly of small kinds, were later described and figured by von Meyer, Wagner, Quenstedt, Plieninger, and other German naturalists, by Owen, Seeley, and others in England, and Winckler in Holland, and by Marsh, Williston, and Eaton in this country. The finest skeletons of these little pterodactyls have been secured from the lithographic limestone of Solenhofen and other places in Bavaria. The Munich Museum has a very fine series of these beautiful little fossils, and many more are scattered through various European museums. Only a few are in American museums. One beautiful little skeleton, perfectly preserved, but no larger than a sparrow, is in the American Museum's collections. It was obtained in exchange for a hind leg of the huge *Brontosaurus* sent to the Munich Museum,—one of the least of extinct reptiles in exchange for a part of one of the greatest. Some of the Solenhofen pterodactyls were of larger size, up to two or three feet spread of wings. Some had short tails; others, such as the *Rhamphorhynchus,* had long slender tails. A few beautiful specimens have been found in the Jurassic limestones of England—notably the *Dimorphodon* and *Ornithodesmus.*

Appearance and Habits of the Pterodactyls

It is chiefly these little pterodactyls of the Jurassic period, all of them

comparatively small and primitive, that have been studied by scientists. Between them and the giant *Pteranodon* of the Cretaceous formations of America and England there is evidently a wide gap, partly filled by the smaller and more primitive *Nyctosaurus* that is also found in the Kansas chalk beds. The earlier pterodactyls look enough like reptiles to be unmistakable, and to afford many suggestions of their appearance in life. They must have been rather quaint little creatures, more bat than bird, but very different from bats in the little reptile head with projecting needle teeth, as also in the long slender wing and the soaring flight. The *Pteranodon,* on the other hand, and this is true too of *Nyctosaurus,* impresses us as having been converted into a great elaborate machine, rather unwieldy, one feels, on account of its great size, and as having lost all resemblance to a real or living animal. Perhaps it was not so, yet the intense specialization of every detail of its skeleton gives this mechanical impression very strongly. I cannot see in it anything beyond a marvelously elaborate mechanism, gigantic in size, perfected in every detail of adaptation to its singular mode of life, automatic and precise in its response to every gust of the changing wind, to every distant flicker of light or shade that might indicate some prospect of prey or warn of a lurking enemy. I can picture him soaring as the great sea birds do today, sweeping tirelessly across the broad glittering surface of the Cretaceous seas, patrolling them from dawn to dusk in search of such unwary fish or pelagic mollusks as might be sunning themselves at the surface and come within reach of the sudden swoop from above. Generally, I imagine, he would avoid actually coming down upon the surface of the water, for that would involve at least a great deal of difficulty in rising again into the air—indeed it is not easy to see how it would be possible for the giant *Pteranodon* to rise from the level sea, save through aid of the wind. At night he would perhaps return to the shore many miles distant, and hang himself up on some favored roost—tree or rocky point—anywhere that would be securely out of reach of the dinosaurs and other fierce reptilian beasts of prey which lived upon the land.

Whether the pterodactyls laid eggs, how these eggs were hatched and cared for, we have no means of knowing. Nor do we know much about their origin and evolution. They appear, full-fledged, in the Jurassic slate and limestone formations of England and Germany; of their early evolutionary stages nothing, or next to nothing, has yet been discovered. Another gap, as we have already indicated, separates these Jurassic pterodactyls from the huge aviating machines that are found in the deep-sea formations of the late Cretaceous. Perhaps these really were the last survivors; perhaps they are but one type of a varied world of flying reptiles whose forms and habitat the rocks have not yet revealed to us. When we reflect on how many discoveries in the terrestrial life of the Cretaceous period have been made during the last quarter century, it may well seem that there is much to be discovered about pterodactyls by diligent and systematic search in the formations of the Age of Reptiles.

European Pterodactyls are Mostly from Stone Quarries

Most of the discoveries in Europe have been incidental to the working of the great quarries of lithographic limestone in Germany; a few have been made in the quarries for roofing and finishing slate at Holzmaden. In England the greensand quarries, worked for fertilizer material, have

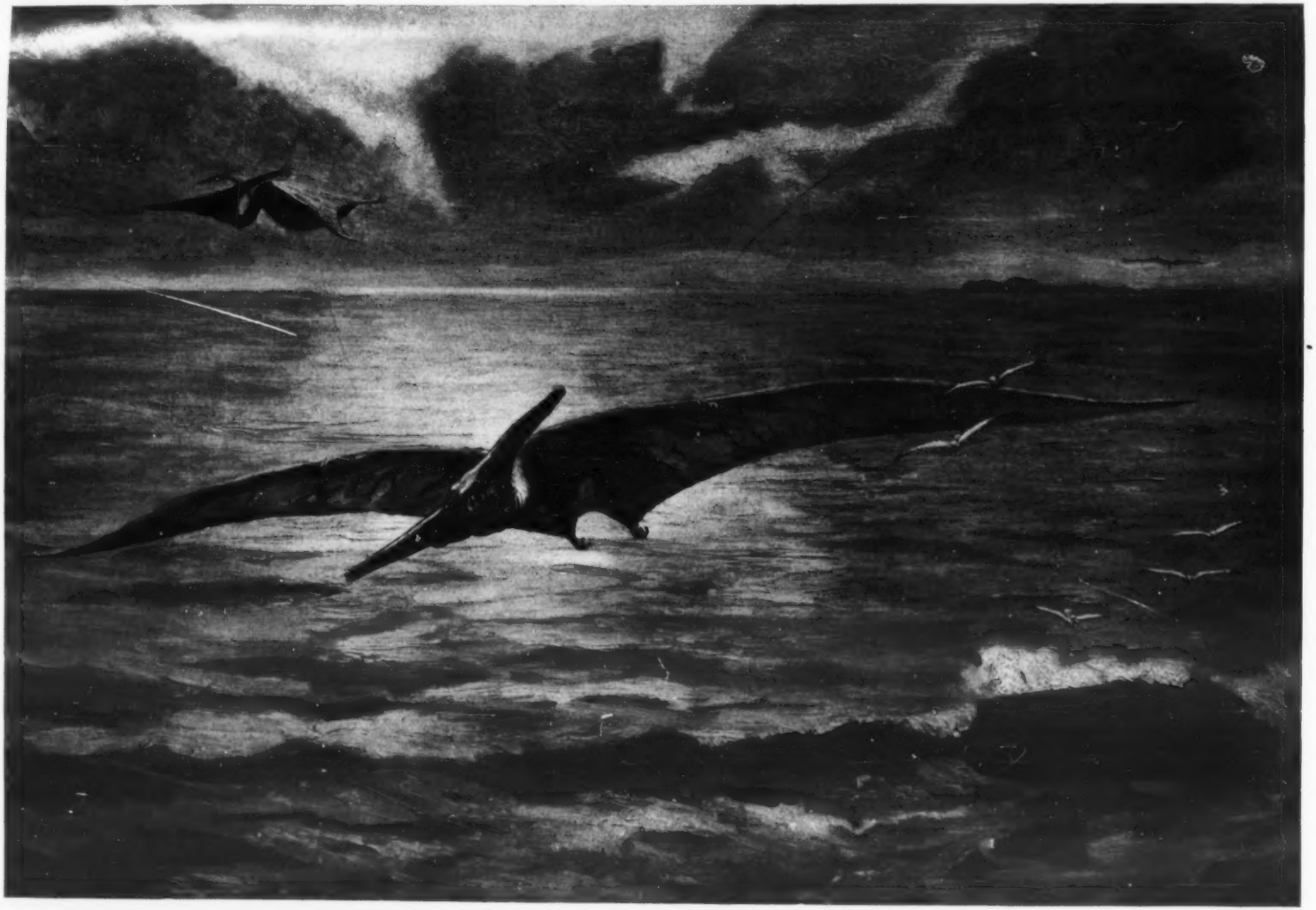
been the most important source of pterodactyl bones. From these sources there is not much to be expected in the future. Lithography is almost a vanished art nowadays, so far has it been superseded by photographic methods of reproducing illustrations. Slate quarries are still worked, but more and more the natural slates tend to be replaced by cement and other artificial substitutes. Greensands as a source of potash have been largely superseded by the German and Alsatian potash salts and other sources. Perhaps the greensand quarries, both in Europe and in this country, may again be extensively worked if some practical process is devised for extracting their potash in a soluble and concentrated form, and thereby reducing the cost of transportation. But any future excavating would be done with steam shovels, and the chance of saving delicate fossil bones would be very slight.

Prospects for Future Discoveries

For these reasons future discoveries of pterodactyls will probably come only as the result of direct and systematic search for these and other fossil specimens. We can no longer hope for them as a by-product of other quarrying operations. How many such quarries will pay to work for the fossils alone we do not know. Some probably will, others will not; an individual study of each will be needed. There is no doubt that the American Cretaceous formations will continue in the future as in the past to yield specimens of the giant *Pteranodon* and its relatives. It may well be also that systematic search would reveal important new sources for specimens of the flying lizards.

Researches Needed in the Mechanics of Pterodactyl Flight

It is also certain that much more could be learned by systematic and thorough study of all the pterodactyl specimens that have been found and are preserved in various museums. Such studies would be most profitable from the point of view of the mechanics of their flight. Researches in aviation during the last few years would throw a great deal of light, heretofore unavailable, on the mechanics of pterodactyl flight. And it is highly probable that this study in turn would aid in some unexpected ways in our practical knowledge of aviation, for the pterodactyl as a flying machine comes distinctly nearer in type to the aëroplane than do either birds or bats. Aëronautic societies or government departments might well find that a grant for research in the mechanics of flight of pterodactyls would be very profitable if wisely expended. And it is but right to say that it would be very easy to expend a good deal of money in such a research, if unwisely directed, without securing any commensurate results of either scientific or economic value. I believe that I could plan the expenditure of from $4000 to $5000 a year for from five to ten years, with a reasonable certainty of obtaining some results worth while, and an excellent prospect of getting data worth many times the expenditure. The success of such a research turns upon the selection of the right men to do the work in field and in laboratory; and I think I know who they are. It is hardly necessary to say that the American Museum would gladly aid in such work so far as practicable.



GIANT FLYING REPTILE

Restoration drawn under the supervision of the late Dr. S. P. Langley, of the Smithsonian Institution. It is supposed that the little white birds which look like gulls are *Ichthyornis*, one of the toothed birds of the Cretaceous period

Wood Turned to Opal

Reflecting colors of the rainbow, with a deep glow of red and orange, as if portraying the ancient volcanic fires which perhaps caused the change

By HERBERT P. WHITLOCK

Department of Mineralogy, American Museum of Natural History

IN Humboldt County, Nevada, in the heart of the great natural wonderland of the West, there have been brought to light quite recently some wonderful fossil remains of trees. These are remarkable not merely because they represent trees which have been turned to stone, but because the mineral that has taken the place of the once soft and porous vegetable tissue is the much sought after opal, which has of late years taken a high place among the popular gems.

To reconstruct the process by which this apparent miracle of nature has come about we must go back many thousand years. We must go back to the time when these trees clothed the mountain-sides or shaded the valleys roamed over by the mastodon and the saber-toothed tiger, a landscape far different from that which we see today from the car window or the pack horse trail. We must conceive this area, which we call Nevada, overwhelmed by some widespread disaster, possibly one of the earthquakes which must have been frequent in such a volcanic region. This reduced the growing forest to a swamp and buried the tree trunks under many feet of water-soaked débris.

It was then, when the trees had become mere water-logged snags, that the work of converting them into opal began. For the water which penetrated to their inmost pores was not the innocent fluid we are accustomed to dip from a wayside pond, but a more or less heavily charged solution of silica, probably heated by volcanic action.

Such a mineral water, gradually, as the wood of the tree yielded to decay, replaced this woody substance, particle for particle, with hydrated silica, often preserving with wonderful fidelity the cellular structure of the wood. Much of the opal which has thus replaced the substance of the wood is of the variety called semiopal, but some of the colloidal silica has been deposited as precious opal, and exhibits all of the beautiful and changing colors of that gem.

A fine and highly representative series of these Nevada wood opal replacements has been put on exhibition in the Morgan hall of minerals at the American Museum of Natural History. In this exhibition all the steps in the process of the remarkable change from wood to opal may be seen. To anyone unfamiliar with the variety of color exhibited by precious opal, the exhibition comes as a positive revelation.

Here one may see clear, glasslike fragments of former trees, which send back to the eye a rich ultramarine shade, like a veritable pool of light. Other pieces flash with brilliant red, orange, blue, and green, shifting and changing with every alteration in the position of the observer. Broad sheets of color and harlequin-like shadings stand in contrast with each other. A particularly unique specimen is of a dark, smoky general color which, when the light is caught at the right angle, reflects a dull glow of red and orange, almost as if portraying some of the fires of the extinct volcanoes which, no doubt, gave birth to its remarkable metamorphosis.

Microscopical Trouble-makers in the Water Supply

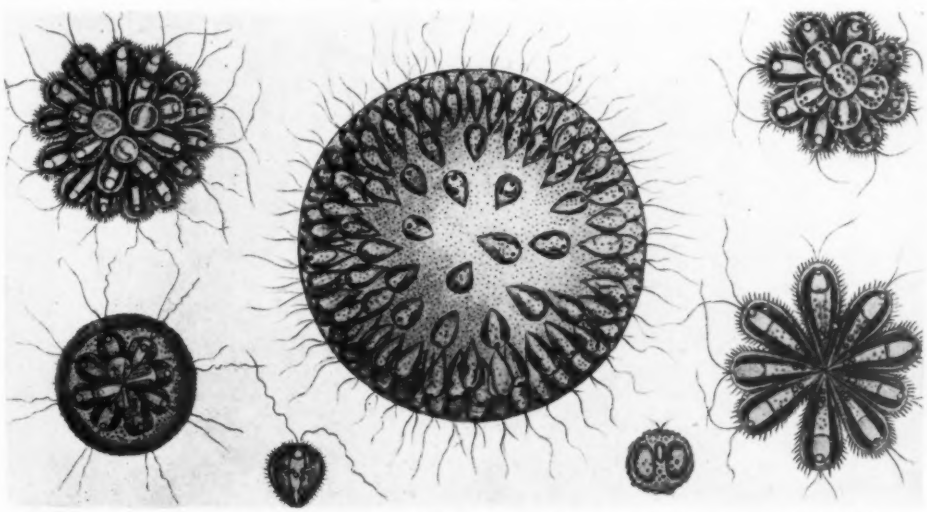
By MORTON CHARLES KAHN

Department of Hygiene, Cornell University Medical College

WE have all, at one time or another, encountered foreign flavors and odors in the water supply, both agreeable and repugnant. For the most part these are due to the presence and growth of microscopical plants and animals. Such effects, together with the presence of turbidity and color, are always looked upon with suspicion by the public, for there is nothing to which a community is more sensitive than something unusual in its drinking water or in its household supply, be it detectable by smell, sight, or taste.

Large and small flowering plants, commonly found in reservoirs and along sources of water supply, such as pickerel weed (*Pontederia*), water plantain (*Alisma*), eelgrass (*Vallisneria*), and many others, rarely cause trouble. While they may be a nuisance in a mechanical way, due to their abundance, or even by contamination since they furnish a place of rest for the more obnoxious forms, still in themselves they are harmless, and produce no direct effect upon water used for domestic purposes. It may be said that although a large accumulation of these plants undergoing the processes of decay, together with other decomposing organic matter, may produce unpleasant flavors and odors, this condition seldom occurs and if it does it is a comparatively easy task to rid a water supply of this trouble.

There remains one group of plants, the algæ, mainly microscopic, which is unfamiliar to most people and much too often neglected because it seems to possess no economic importance. This is a mistake, for these microscopical

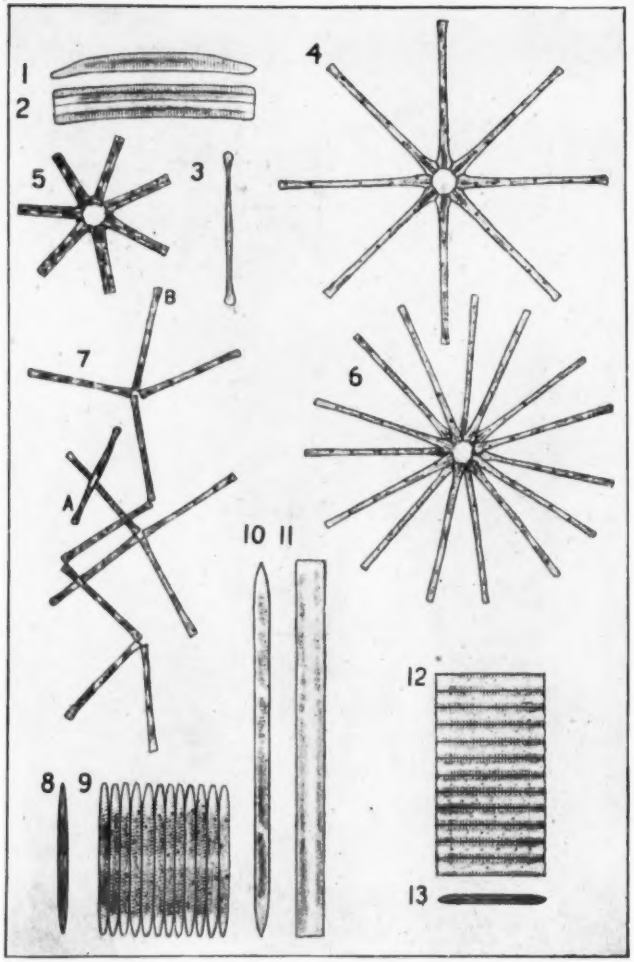


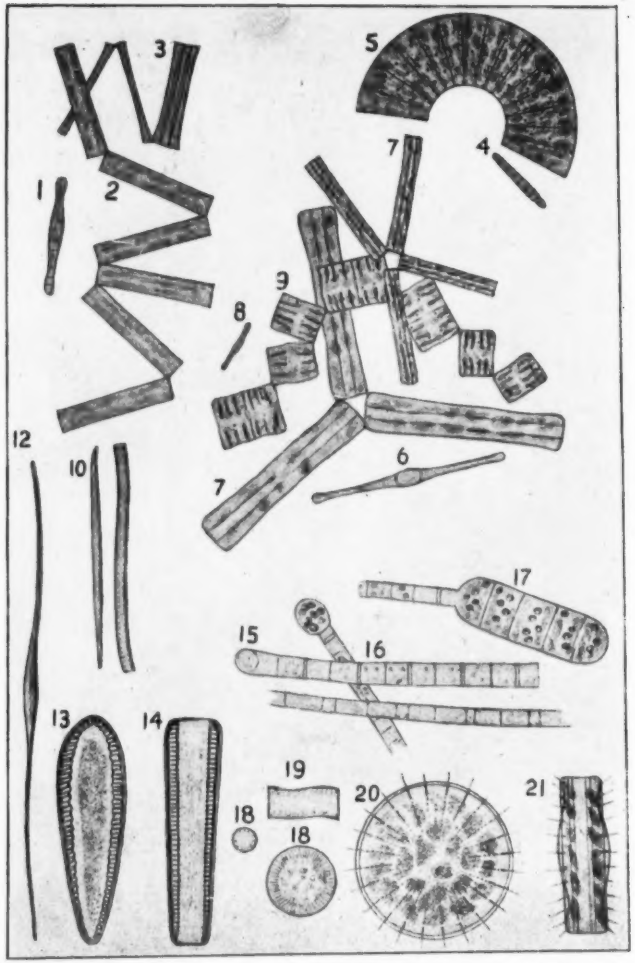
The most important contaminators of any public water supply are not weeds or large animals but one-celled plants and animalcules and pathogenic bacteria. The peculiar oil found in *Uroglena* (center in illustration) and liberated when this microörganism is ruptured, is a source of the disagreeable fishy and oily odor sometimes characterizing a public water supply. The *Uroglena* (claimed alike by botanists and zoölogists) grow in colonies, single-celled bodies embedded in the surface of a gelatinous sphere. Only the slightest pressure is required to break the delicate structure—even the pressure of water in a stand pipe or the disturbance caused by pumping. The other forms in the illustration are *Synura* and *Syncrypta*. Bad odors, especially cucumber odors, have in the past been traced to *Synura*, both in the Boston supply and in the Croton supply of New York. Even so few as five or ten colonies to a cubic centimeter will cause a perceptible odor. Strangely enough these forms are sometimes most numerous in winter just underneath the ice

DIATOMS IN THE WATER SUPPLY

The microscopic diatoms may cause disagreeable odors in drinking water. A diatom is very beautiful seen under a microscope, geometrical in design, with two transparent valves, fitting one into the other like a shallow glass box and its cover. The valves are variously marked with points or grooves so minute that from several hundred to several thousand occupy a mil i-meter. These increase the friction of the diatom with the water and tend to prevent it from sinking—for a diatom is heavier than water, yet must float near enough to the surface to get sunlight for growth. The silica in the valves has commercial value: deposits of many generations of diatoms form "diatomaceous earth" which reaches the market in various polishing powders, including tooth powder; also as an absorbent for nitroglycerin in the manufacture of dynamite. The illustrations show common diatoms in both valve and face views; 3 and 4 (at the left) are *Asterionella* which may give a fishy odor to water; 6 illustrates the rapid multiplication of *Asterionel'a* by division.

Diatoms may also prove troublesome in water used for laundering or for paper making because of their greenish yellow pigment, similar to the chlorophyll of green plants.



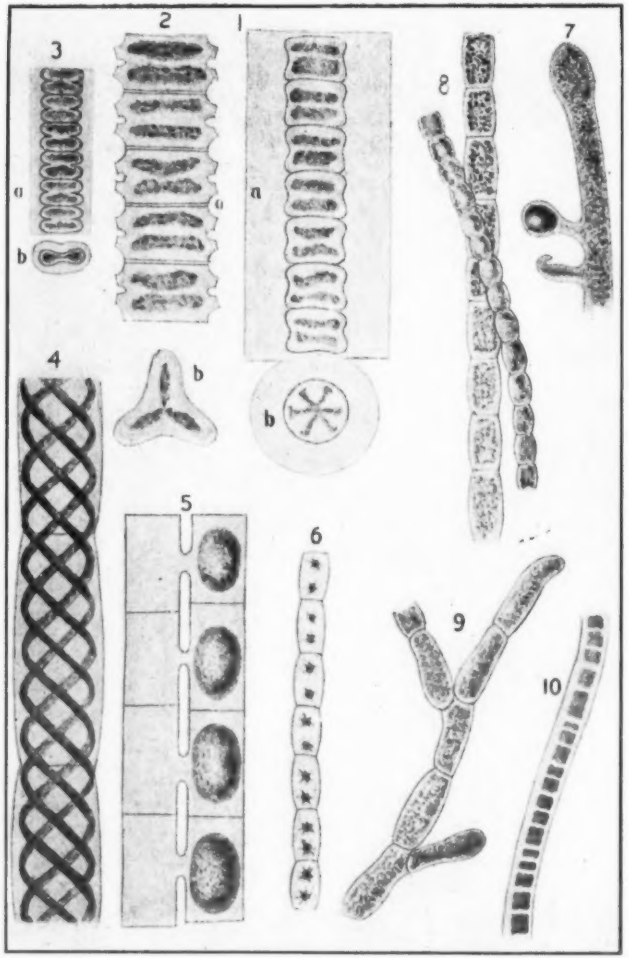


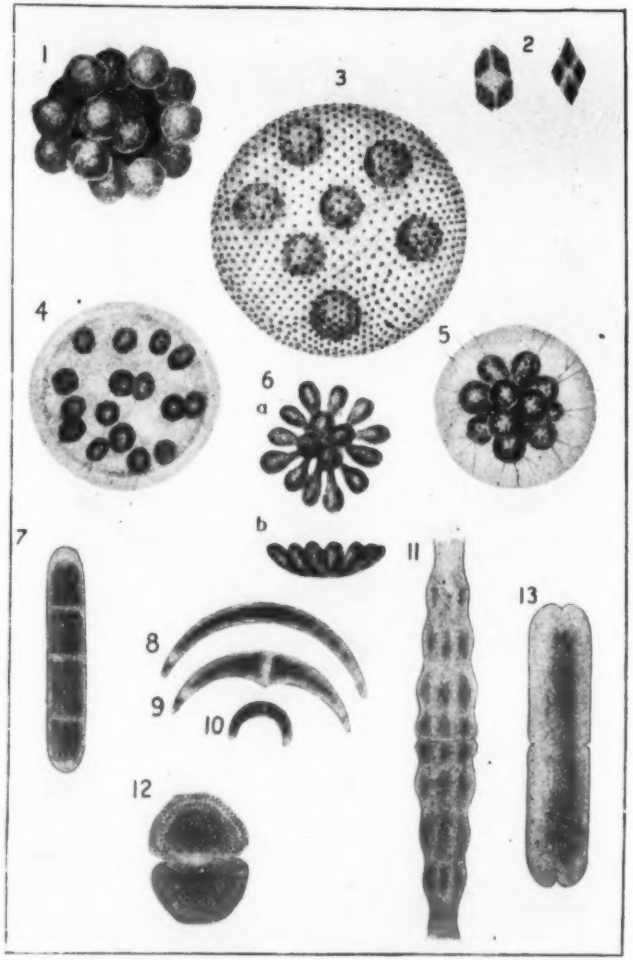
Myriads of diatoms swarm in the plankton of both fresh-water ponds and of the sea where they supply an important diet for fish. It is said there are nearly 10,000 species. Various species may appear in a pond in succession during the year, and different species in different years. Some species have a spring and fall period of maximum growth, such are *Synedra* (8–11), and in the illustration at the right *Diatoma* (1–3) and *Tabellaria* (6–9). In general, diatoms do not require a high temperature for growth. Some species are actively motile, probably as a mechanical result from the liberation of oxygen during photosynthesis. A water supply containing diatoms or other minute plant forms must be purified by aëration and filtration in the reservoir

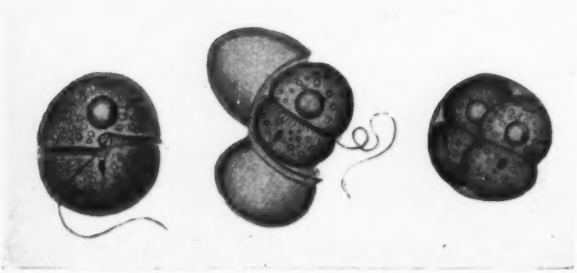
MINUTE WATER PLANTS

The common bright green scum of our ponds is frequently formed of masses of the long, many-celled *Spirogyra* filaments, with their beautiful spiral fronds. This plant is shown in 4, at the left, also in 5 after the formation of zygospores, each made by union of the cell contents of adjoining filaments. Not the least of the damage occasioned by this plant is that it causes the larger water plants to decay by forming a scum so dense that they are choked out. Water cress grown for market in winter beds may sometimes be destroyed in this way. Other filamentous algæ of great beauty and interest for the botanist, but which have natural odors and may be sources of disturbance in reservoirs of water supply, are (at the left) *Hyalotheca* (1), *Zygnema* (6), *Vaucheria* (7), *Conferva* (8), *Cladophora* (9).

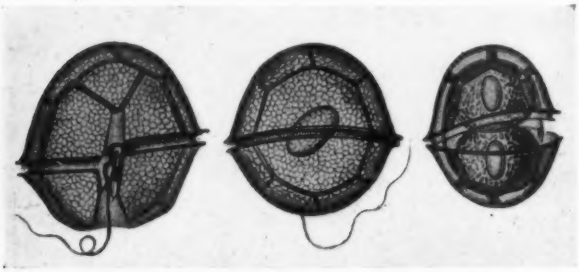
A form such as *Volvox* (at the right, 3), is especially adapted for floating at the surface of the reservoir. It consists of a gelatinous sphere often one millimeter in diameter in which the several thousand microscopical cells (black dots in the drawing) are embedded, with their cilia pointing outward. By the beat of this multitude of cilia the sphere, which is lighter than water, is kept rotating and moving about independently like an animal. This form contributes a strong fishy odor and must be filtrated from the water supply. It reproduces rapidly through development of daughter colonies by division of cells (the darker inner spheres). Such forms as *Eudorina* (4) and *Pandorina* (5) also may give a fishy odor to the water







It is said that *Glenodinium* imparts a fishy odor to water in which it grows, but the species is not common enough to be an important source of trouble. In gelatinous masses on the water it shows phosphorescence



Peridinium is a consort of the diatoms in the floating life of lakes and reservoirs and especially of the sea. It is not sufficiently abundant to be troublesome in the water supply, but it is said that it produces a fishy odor "like that of clam shells." Both this and *Glenodinium* are enclosed in shells of cellulose, and contain chlorophyll and starch granules and so are frequently classed with plants

plants have a real influence on the general public welfare, in that they are direct causative agents for practically all of the bad odors and flavors in drinking water and, besides the bacteria and a few protozoans, are the only organisms which need be taken into account when considering the biology of drinking water from a hygienic standpoint. Some of the algæ may be seen with the naked eye, that is of course when they occur in vast numbers so as to form a scum on the water's surface. Most of them may be seen only with a microscope, and it is only by the aid of this powerful magnifying instrument that any of their individual structures can be studied. Their structure too, for the most part, is very beautiful, forming one of the most fascinating fields of microscopy.

Let us first consider the diatoms, a great group of trouble-makers belonging to the algæ. It is known that some of them give rise to serious trouble in the water supply.

Water inhabited by excessive numbers of these organisms most frequently develops a very disagreeable fishy odor. Some people think the odor like that of geraniums. Personally, however, I think it far less agreeable than the fragrance of this common garden flower. The specific types of diatoms which cause the disagreeable conditions are: *Asterionella,* responsible for the distinct fishy smell, and *Tabellaria, Meridion,* and *Diatoma,* when they become numerous. When sparse, on the other hand, they are possessed of a distinct aromatic principle, which is not considered disagreeable. Diatoms are exceedingly troublesome when contained in water used for laundry purposes, or for the manufacture of paper. This is due to the fact that they contain a greenish pigment, which stains articles coming in contact with it.

Structurally a diatom is very beautiful. It may be described as resembling a glass box made up of two halves, one fitting tightly within the other, the walls being strongly silicified. Diatoms are not without their redeeming features, for it is this silica contained in diatomaceous earth that makes it valuable as a polishing powder. Earth containing diatomous remnants is used to some extent in the manufacture of dynamite. Diatom shells form no mean portion of certain of our well-known brands of tooth powder, and last but by no means least, the living marine types

form an important part of the diet of some of our food fishes.

The methods used for multiplication by these members of the Diatomaceæ, are unlike anything of a similar nature found elsewhere among the algæ. The two valves or halves of the organism begin a slight process of separation, and as the contents divides into two parts, there are formed within, two new halves, one fitting into the larger half of the original cell, and the other forming a new box within the smaller half of the parent cell. These then separate, forming exact counterparts of the mother cell, although one is a trifle smaller than the other. In addition to the above mentioned method of reproduction, the plant also possesses the power to form a large spore, making it more or less resistant to adverse conditions; also, it has been noted that the diatom cell may break up into a number of much smaller spores, each one capable of developing into a new plant.

One organism claimed alike by botanist and zoölogist, but at any rate a trouble-maker for the hygienist, is *Uroglena,* belonging to a group known botanically as Syngeneticeæ. This form demands especial attention, for it is probably responsible for more trouble in the water supply than any single representative of the various groups of microscopical plants, excluding of course the pathogenic bacteria.

Uroglena is widely distributed over the United States, but is more frequently encountered in New England and in some of our middle western states, Indiana, Ohio, and others. *Uroglena* lives in colonies in appearance resembling a colorless sphere, with a large number of greenish cells embedded in the periphery. Usually much smaller than one half a millimeter in diameter, the *Uroglena* colony may however attain that size. Each individual cell is equipped with a pair of cilia of unequal length, and it is by vibration of these hairlike appendages that the colony is propelled through the water. Each cell of the colony contains in addition to a well-defined nucleus, which appears as a red spot, a single greenish colored body, and several vacuoles. By far the most important content of the cell from a sanitary standpoint and the one that causes the organism to be feared by those responsible for the water supply, is the large number of oil globules. It is the liberation of this oil that causes all of the trouble, namely the detested fish-oily odor usually attributed to water containing this form of life. The oil seems to be held in rather loose combination, so that the mechanical breaking of the colony serves to liberate it in sufficient quantity grossly to contaminate the water. The cells of *Uroglena* are, unfortunately, very fragile, and much force is not required to rupture them and liberate the oil. Usually mere pumping, or even the force of gravity through pipe lines necessary to distribute the water, is enough to cause the disturbance. The exact nature of the oil is not very well understood. It is believed that it is not unlike the so-called essential oils, being nonvolatile at the temperature of boiling water, and seeming to resemble the oils obtained from some of the diatoms and blue-green algæ.

The methods of cell division in *Uroglena* are somewhat peculiar and decidedly interesting. Before dividing, the cell seems to turn in the periphery of the hollow gelatinous sphere, until it is at right angles to the position usually occupied. Then at the end of the cell which originally pointed toward the center of the sphere, there is formed a pair of cilia similar to those at the opposite pole, and the appearance of the characteristic spots of red is then noticed. The cell begins to be sharply constricted, and as it gradually divides, the two halves are drawn back through an angle of about 45°, so that when the cells are finally formed, they

occupy a position similar to the one normally assumed by the parent. When a cell colony becomes too large, it divides into individual cells, and these by numerous processes of division soon grow into new spheres. In addition *Uroglena* is also able to form spores, so that it is quite ready to survive periods that would normally lead to its extermination or at any rate seriously handicap its multiplication. Queerly enough, *Uroglena* seems to thrive best during the cold winter months, especially when the surface of the water is frozen. In Europe just the reverse is true, July and August are the months most favorable to its growth, and it disappears altogether at the approach of cold weather. For this reason many seem to think that the European and American types are different species.

Among the microörganisms found on the surface of pools are several claimed by both botanists and zoölogists. Such is *Eug'ena*, a minute free-swimming organism with a flexible whiplike flagellum near the mouth. Immense numbers of *Euglena* may collect in a green or reddish scum on the quiet water of ponds or reservoirs

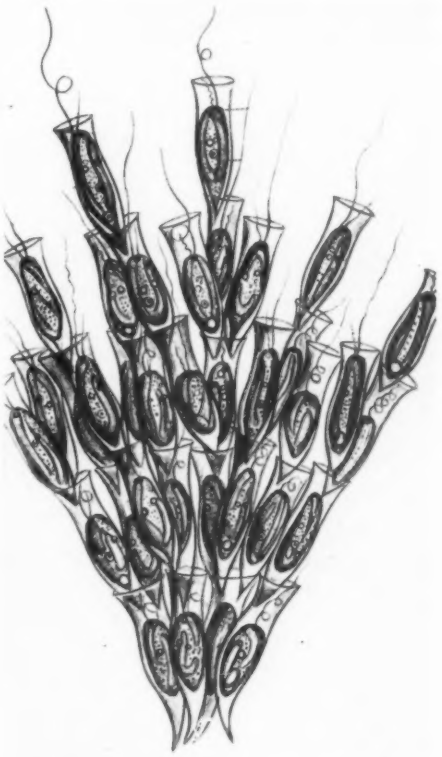
Other Syngeneticeæ are concerned with the contamination of water, but usually not to the same extent. *Synura* and *Syncrypta* are both accused of having a bad effect, *Synura* being responsible for the offensive "ripe cucumber" odor formerly thought to be caused by fresh-water sponges.

Without doubt *Uvella* should be spoken of, as it is one of our most dreaded forms, and to it has been reputed the cause of an acid taste in the water which is most disagreeable. It greatly resembles *Synura* and many believe it to be the same organism; it differs, however, from that form in the lack of a separate investing membrane, and by the posterior location of the contractile vacuole. There are also few zoöids contained in the cluster.

Another very bothersome water microörganism, which may be the cause of much annoyance, is the common *Spirogyra*, which has been known to cause thousands of dollars' worth of damage by smothering growing water cress in artificial beds constructed for the winter propagation of this salad plant. When the cress is cut for market, the mutilation leaves the plant in a much weakened condition, and if *Spirogyra* gets a start, it forms a thick mat over the surface of the water, preventing the growth of the cress, and often killing the entire crop in a given district.

Anabæna, one of our most important water contaminants belonging to the order Nematogenæ, surely merits

more than a passing mention. George Chandler Whipple, professor of sanitary engineering in Harvard University, in a graphic description of the serious amount of trouble this form may cause, tells how the large Chestnut Hill Reservoir, Boston, was contaminated by *Anabæna*. This blue-green algal form multiplied to such an extent that in the course of a comparatively short time it polluted the entire line of supply of the communities getting their water from the above-mentioned source. In structure and form *Anabæna* much resembles an irregular chain of green beads. The vegetative cells are from five to twelve microns in diameter, depending on the species. It possesses both spores and peculiar dead cells called heterocysts. Being one of the most abundant producers of obnoxious oils, it causes annoyance in much the same way as does *Uroglena*.



Some of the protozoans as *Dinobryon* collect to form simple colonies which may be either attached to objects in the water or free-swimming. New colonies are formed and dispersed by spores so that large numbers of the animalcules may be generated within a brief period if conditions are favorable. *Dinobryon* is classified as giving to water a fishy odor, "like rockweed." All odors given off from decomposing microscopic organisms are offensive, especially so when they contain a high percentage of nitrogen

Stentor never exists in sufficient numbers to become a pest and is for the most part negligible from the hygienic point of view. Rapidly vibrating cilia at the top where the mouth is, maintain a current which carries in food particles. *Stentor* may either attach itself to some foothold or remain free-swimming

Among other forms giving rise to unpleasant odors and flavors are *Dinobryon, Bursaria, Peridinium,* and *Glenodinium*. They are not often causes of bother, and are interesting for the most part because of their unusual structure, and like many other microörganisms show the varied forms of plant and animal life which may exist in a given source of water used for domestic purposes.

To Dr. G. T. Moore, head of the Department of Botany, Marine Biological Laboratory, Woods Hole, and Mr. K. F. Kellerman, associate chief of the Bureau of Plant Industry, Washington, D. C., two of our most efficient experts on water biology, belongs the credit for suggesting a very good means of controlling these minute pests. The method consists of using small amounts of copper sulphate, a chemical which seems to have a specific toxicity for the lower forms of life. The requisite amount of copper sulphate is placed in a sack of coarse cloth, and drawn slowly back and forth over the surface of the water in the reservoir. Diffusion and the natural circulation of the water serve to mix the chemical and distribute it to all parts necessary. According to Professor Whipple the amount of copper sulphate to be used varies with the following factors: 1, organisms present; 2, temperature of the water; 3, the amount of dissolved organic matter; 4, hardness of the water. In the case of the more susceptible organisms such as *Uroglena* and *Anabæna,* dilutions of one part copper sulphate to five to twenty million parts of water is sufficient, while for the more resistant forms such as the diatoms, the amount required to produce a lethal effect on the species may be as great as one part of the chemical to one million parts of water. Fortunately, the organisms giving the greatest trouble are the ones which most easily succumb to the copper sulphate method of treatment.

Objections have been raised against this method, due to the poisonous nature of the substance used as an algæcide. There is little reason to believe that there is much to be feared, however, considering the high dilution of the chemical when it ultimately reaches the consumer, especially when the use of copper sulphate is followed by filtration of the water, for by filtering, the copper salt is largely removed. Much of the chemical is bound by the ever-present vegetation, while still another portion is precipitated. The use of the copper sulphate method of treatment is not advised, however, without expert supervision.

Pathogenic bacteria do not make the water unpalatable and thus are often tolerated in a water supply for a long time; not until there has been an alarming increase in the death rate from water-borne infections, is their injurious presence brought home forcibly to the general public. With algæ it is different, their presence for only a day or two will cause the water to become offensive to such an extent as to make the general rate of water consumption in the community fall far short of the amount needed for physical well-being. Even when a water supply is palatable in every way, people tend to drink far less than is normally needed. Just stop and consider what a vital substance water is: "Seventy per cent of our body weight is composed of it; it enters into the chemical composition of all of the tissues; it forms the chief ingredient of all fluids of the body and maintains their proper degree of dilution, and thus favors metabolism; by moistening various surfaces of the body, such as mucous and serous membranes, it prevents friction; it furnishes in the blood and lymph a fluid medium by which food may be taken to remote parts of the body and waste material removed, thus promoting rapid tissue changes; it serves as a distributor of body heat; and it regulates the body temperature by the physical process of absorption and evaporation."

One of the most common dietetic faults is neglect to take enough water into the system. It is important, then, to have a pure and wholesome water supply that may be partaken of with enjoyment by all.

Courtesy of the New York Times

A river of mountain water, at least 250 million gallons daily, is carried from the Catskills to the people of New York City, 100 miles to the southward, by means of one of the most splendid pieces of engineering work the world has ever known. Before starting on its long aqueduct journey the water passes through the great fountains of the Ashokan aëration plant.

It is the pleasure of NATURAL HISTORY to announce publication in an early issue of an article by Dr. Charles P. Berkey, of Columbia University, on the Catskill water supply of New York City. Dr. Berkey was geologist during the ten years of preparation and of active operations at Ashokan and elsewhere on the new system

The Fountains of Ashokan[1]

By ROBERT UNDERWOOD JOHNSON

Henceforth what dream can e'er efface
  Ashokan's pure and irised throng?
Not Dryads, nor the Dryads' grace,
  Not Naiads, nor the Naiads' song.

Like ghosts of cedars, cool and tall—
  They mount close-clustered row on row—
As white as when the moonbeams fall
  Upon the newly fallen snow.

Yet they are not a thing of night,
  But souls of nymphs that stand by day
Poised for a fellowship of flight
  While with their robes the breezes play.

They live in light—not spirits dire
  That haunt the darkness—not to harm,
But like a massed angelic choir
  With songs of benison and charm.

For not of Death their waters speak
  But Life, these glad Ashokan towers:
In heavenly ministry they seek
  The city's human weeds and flowers.

Ah, could they flash their song and sight
  To house and hovel as they pass,
How urban toil and care and blight
  Would quaff new beauty with the glass!

[1] By permission of the Author and of Yale University Press.

For the Sake of His Ancestors

By MALCOLM P. ANDERSON

FOREWORD.—Mr. Malcolm P. Anderson, who lost his life in patriotic service in a California shipyard in the third year of the war, was an explorer and field collector who had a future of unusual promise. Previous to 1904 when he received his degree from Leland Stanford Junior University, he had tramped thousands of miles while studying the fauna and flora of California and Arizona, and had accompanied an expedition to Alaska. From 1904 to 1908 he acted as leader, chosen by the London Zoölogical Society, of the Duke of Bedford's Expedition to Eastern Asia, under the immediate direction of Mr. Oldfield Thomas, mammalogist. In 1909–10 he returned to the work, traveling much in China, in the desert to the north beyond the Great Wall, and in the mountains on the border of Thibet. Later he went on two expeditions to South America. The following is an extract from a letter to the Editor, written by his father, Melville B. Anderson, professor emeritus of English literature at Leland Stanford Junior University, to accompany the manuscript of the Chinese story:

"This story of Chinese life by my son, Malcolm P. Anderson, is hardly of a nature to appeal to the jaded taste of readers of our garish story magazines. It is a plain tale plainly told by one who was far more expert with the implements of the field collector than with the pen. If I venture to offer it to you for publication, I do so because I deem it of distinct value for minute fidelity to the facts, the tone, the color, the feeling of the human scene, which is set in a mountainous region of one of the remote provinces of China. With such scenes my son became familiar during long, lonely months and years spent in the wilder parts of that empire while engaged, as head of the Duke of Bedford's Expedition to Eastern Asia, in making those collections which Mr. Oldfield Thomas has praised as among the best of their kind.

"Doubtless I am no impartial judge, but perhaps you will permit me to say that I find great charm in the somewhat archaic simplicity of the style of this tale—a simplicity which those who knew the author will recognize and esteem as of the essence of the man himself. Let me add that he was not unaware of a certain scanty sufficiency in the evidence offered at the trial for the conviction of the robber and false accuser; and that he had planned an important change in the plot, involving a re-writing of the latter part of the tale. But I cannot bring myself to tamper with what is written. I feel that changes made by another hand would introduce a jarring note. As the little, unpretending narrative stands, there is scarcely a sentence which is not suffused with Chinese atmosphere; at all events these beings breathe an air that is different from ours; yet different as is their moral atmosphere, the tale helps us to realize that they are human equally with ourselves. Therefore it does attain one of the great purposes of art."

I

IT had been market day in Ling-tai-miao, and Lao Fung, the village storekeeper, had made a number of good sales of cloth shoes, rice, and dried persimmons. Now when the winter evening had come, and the shutters were up before the shop, he sat by his table counting his gain.

The little old Chinaman was wrapped in a heavily quilted blue gown, the long sleeves of which were rolled back to give him the use of his hands. At his feet burned a charcoal brazier, and on the table stood a rush lamp casting a feeble light on the dusty shelves of merchandise, the piles of brass cash on the table, and on the wrinkled face of Fung.

Deftly and quickly the practiced teller arranged the coins in a tier in his left hand, and counted them by fives as he passed them to his right. His task was almost finished when a voice addressed him through the shutters, which alone separated the shop from the street.

"Lao Fung, admit your most humble servant, who has come far to speak with you."

The old man was startled, but replied at once, "Who is the gracious speaker?"

"I am Han of the mountain-side," came the answer. "I come to settle my debt with you before the close of the year."

Fung quietly drew out his strong box and laid the cash away. Then he went out of the room into the courtyard, where he opened the small door in the bottom of the great gate which formed the main entrance to his house. There entered, bowing, a tall young peasant followed by a little girl of no more than six years. The man was hatless, and dressed in a faded blue gown. The child wore a dingy, red-flowered jacket, and pantalettes of green that came to her ankles. On her head she had a hood of red.

The master of the household, with profuse apologies for his dilapidated establishment, led them into his place of business. A long conversation followed, during which Fung eyed the child closely, and appeared to be making up his mind about something. Finally Han came to the real object of his visit.

"Honorable Fung," he said, "my farm has yielded me next to nothing from the last harvest, and I am not able to pay my debt to you in silver, as I agreed to do. During the great rains the mountain sent down a landslide which destroyed much of my land beyond redemption. The burial of my father has taken every ounce of silver I have been able to save for years, and now that the time of settlement has come, I have nothing to offer you but the services of this child, my daughter Ma-wu. She is dutiful, and will be faithful till I am able to purchase her liberty."

Fung looked at the child again. She was a quick, bright-eyed little person, and seemed to understand what was taking place, yet she showed no fear.

"Is the child strong and in good health?" asked Fung. "What work can she do?"

"She can carry crops from the fields, and fuel of twigs and grass from the hillsides. She can clean the pots in the kitchen. She always does as she is bidden."

"Very well," said Fung, "I will take the child on probation, and if after a month I find her satisfactory, I will cancel your debt."

Thus Han sold his youngest child into slavery, but Han was not a bad man. He simply followed the custom of the Chinese peasantry when hard pressed by debts. Had not his own sister been enslaved in much the same way?

Weeks later, Lu, the wife of Fung, sat by her gateway with some of the village gossips. Although it was still winter, the afternoon sun had been bright and pleasant, and these women had taken advantage of it to warm themselves and breathe the fresh air.

"There comes your new servant child," said one woman to Lu, looking down the village street. Ma-wu was to be seen coming slowly along with a rake in her arms and a large basket of twigs and pine needles on her back.

"Yes, but see how slowly the lazy child moves," responded Lu. "She has been out since noon, and has gathered no more than fuel enough for tonight. I wish Han would take her back and pay his debts in silver."

"Look at the clumsy child!"

Ma-wu had stumbled on the rough pavement, and overbalanced by her large burden, had fallen, scattering part of the fuel in the street. For a moment the child lay struggling to be free of the heavy basket; then she was helped to her feet by a traveler, who came up accompanied by a tall boy. The lad hurried about, gathering up the scattered twigs and replacing them in the basket. When this was done he said in a cheering voice:

"I used to gather fuel until I got large enough to help Father at his trade. It was hard work, too, for in our country we don't have the trees and bushes and tall grass you have here in the mountains. Where do you live, little Lotus Flower?"

Ma-wu pointed to the door where the woman sat, and turned to enter as he asked the question. She was too young to know how to answer the boy or thank him, but she felt gratitude, and was happier because these people had been kind to her.

As the travelers went up the street, Shan-liang, the innkeeper, stood in his doorway. The father and the son noticed the inn, paused, then entered, and asked for accommodation for the night.

The host was a kindly old man, who, without being avaricious, had gathered enough wealth to place him second to Lao Fung in the estimation of the villagers. Personally he was far more popular than Fung, for the latter was a hard taskmaster and had a reputation for bad temper.

Shan-liang welcomed his guests as they entered. It was polite to show interest in their affairs, so he asked them questions.

"Honored guests, where have you come from?"

"Today we have tramped from Fen-shien. We have been twenty days in coming from the province of Honan, where is the home of our ancestors."

"And why do you and your son travel?" asked Shan-liang. "You carry no merchandise."

"No, we are seeking a new place to settle. I am a smith, and my son is my assistant."

"Then here is the very place for you," exclaimed the old man. "Our poor village is small, and could give you but little custom, but this road is a highway across the mountains, and is traveled by many mule trains and retinues of officials. Often strangers ask to have their mules shod, and I have to send them away unsatisfied. Now what is your honorable name?" he concluded.

"My base name is Shu, and my son's name is Gan," answered the traveler.

The lad had been looking up at the mountains that rose on east and west. Now he spoke for the first time:

"What mountains you have here, and what forests! On those heights there must be great trees and wild animals."

"Yes," replied the innkeeper, "there are wild animals nearer than that. The boars and deer eat our crops on the hillside yonder.

"Father," said the boy, "with the forest near it will be easy to get charcoal for our forge. We can even go on the mountain and make it ourselves."

"That is true, and since you like this place so well, we will look about the village tomorrow, and perhaps build our shop here."

So Shu and his son became residents of Ling-tai-miao. They built their shop of sun-baked bricks, selecting a spot at the upper end of the village, a rocky place between the mountain and the river that none other had cared to claim.

II

Gan and his assistant, Pang-tze, swept up their smithy after a busy day, and as they finished, these two active young men laid plans for the morning.

"Take down the guns, Pang-tze, and make them ready," said the smith. "There will be no shoeing of mules till next market day, so we may as well go on a hunt."

"I'm out of powder and slugs," said the tall Pang-tze, "but perhaps we can get some saltpeter from old Fung. What shall we hunt, the deer or the boar?"

"Anything we come across," replied his master. "I have sulphur and charcoal. You get some saltpeter, and we will make powder in plenty."

They spent the evening in preparation, cutting some slugs from a bar of iron, cleaning up their matchlock guns, loading them, and covering the lock of each with the skin of a badger, to keep out the snow.

Early morning found them tramping up the steep mountain toward the forest, their guns slung on their backs, and their sandaled feet shod with iron spikes to help them cling to the icy trail.

All day they climbed upward through the forest, but no game crossed their path. Near nightfall they made their way to the foot of an overhanging cliff, which gave them shelter. There they lighted a fire and toasted their crude corn cake in the ashes. They slept as they sat, for within their cavern there was no room to lie down.

Daylight found them ready to start again, and both hopefully for the day's hunt. Together they climbed to the high ridge above their camp, and there in the snow they found the tracks of a herd of great wild goats.

Stopping in a pass they laid their guns down side by side and stuck two sticks of incense in the snow. These they lit, each tending to his own, and Gan prayed to the spirit of the mountain and the ghosts of his ancestors to give them success in the hunt.

The long prayer ended, Gan turned to pick up his gun, and found that his incense had fallen down and gone out.

"Here is a bad omen!" exclaimed he. "What am I to make of that?"

"The spirits must be angered at some deed of yours. They do not favor our hunt, and I fear that this means some ill besides," answered his companion.

"I will leave the hunt here," said the disappointed young man. "Your incense burns still, Pang-tze; you follow the game. I will see you as soon as you return to the village." With this Gan started off down the mountain, but the other strode out along the ridge in the direction the animals had taken.

It was afternoon when Gan reached Ling-tai-miao once more. Going straight to the inn he found his old friend Shan-liang.

"How has the hunt gone?" inquired the old man.

"Badly," was the answer. "We have found only a badger for our trouble. While I was praying to the spirits my stick of incense fell, and I left the hunt for fear of spoiling my friend's chances. Tell me, is there something wrong in the village?"

"There is trouble, indeed," replied the innkeeper. "A few days ago there came a mandarin with a large following. I had not room enough for them all, so the lieutenant and some others went to Lao Fung's, as his is the largest house. Next morning when they left, they discovered that a valuable robe of snow leopard skin had been stolen. Fung himself is blamed for the theft, though not directly accused. I know nothing of the matter, but the villagers think he is guilty."

"What does he say? Has he any explanation?" asked the smith.

"No, the cowardly old fellow charges his slave, Ma-wu, with the crime."

"That's outrageous!" exclaimed Gan. "But tell me, what could induce Fung to steal?"

"Well, we all know, honest Gan, how bitter he has always been against the mandarins for taking so much and paying so little. So I fancy it rankled when he had to receive this traveler, and feed and attend him, with no chance of payment. Perhaps he decided to reward himself. The whole village knows how avaricious he is."

Just beside the inn door was the booth of

the soothsayer of Ling-tai-miao. It was this man's business to tell the people where to bury their dead, when to plant their crops —in short, he ordered the affairs of the community by means of necromancy. When the smith left the innkeeper he consulted this worthy, as he had often done before, and told him of the bad omen that had befallen. The soothsayer interpreted the sign as Pang-tze had done, and directed Gan to satisfy his ancestors by carrying out the plans that their spirits were suggesting to him.

The matter uppermost in the young man's mind was the danger in which Ma-wu stood, so the fortune teller's words meant to him that he was to champion her.

Since that day when he, as a boy, had helped the little slave girl in the street, he had seen her often, and they had been in sympathy, although there had never been much conversation between them. He had seen the child grow into a young woman, and was aware that although she was only a slave, and had not had even the chances of the other village girls, still her disposition was sweeter than theirs. She was prettier, too, for her outdoor work had given her health, and her regular-featured face bore naturally the dainty rose color that the rest attempted to produce with flower stains.

In the early evening Gan went down the long street and into the courtyard of Lao Fung. In the shed that served as a kitchen he found Ma-wu in tears, but still at her work, feeding the fire with bundles of bean stalks, and boiling the rice in the huge kettle.

"Ma-wu," he said in his kindly way, "you work and you cry. Is there something wrong in your heart?"

"Master says the soldiers will come tomorrow, and I must go to prison for stealing a leopard skin. Kind smith, I know nothing of the lost skin. Do not let me be taken away. Here at home they are hard and cruel, but there in prison, they say, people suffer from terrible disease, and die of hunger."

For a moment the helpless girl clung to the young man and felt confident that his strong arm could save her. The open-hearted, unconventional mountaineer was touched by this appeal of innocence, and much distressed on the girl's account. He knew well that nothing could be done without money to buy the interest of the officials, but that Ma-wu might feel a little relieved, he said:

"It is not likely that the runners will come soon. They are never prompt. When they do come I will do all I can. I think I know who really stole the robe, and maybe we can get him taken to prison. You know you have many friends."

At this moment the corpulent and ill-tempered Lu appeared, and seeing the fire out and the rice but half-cooked, she became enraged and beat the defenseless girl with a heavy sash she carried. Gan immediately stepped between the two. Anger was in his eye, but he said not one word. The mistress, dropping her arm, resorted to her tongue, and delivered a tirade of imprecations against the two young people.

Ma-wu was quite used to such treatment, and turned again to her fire and pot. Gan pretended not to hear the old woman, but bowed ceremoniously, and departed without speaking.

Arriving at his home the smith found that Pang-tze had returned. The hunter had killed one of the large goats, and had come back for some one to help him carry the flesh home. He brought with him some of the parts most prized by the villagers, among them the heart and lungs. Gan saw this, and formed a plan at once.

"I cannot return with you, Pang-tze," he said, "but you will find others willing to go, just to get a little of the blood or a taste of the meat." Then after a pause he added, "May I ask a favor of you? I should like the heart and lungs."

"They are yours," replied Pang-tze. "If you could have remained on the mountain with me the animal would have been half yours, anyway."

"I want to talk with old Fung, and I fear he is in a very ill humor," said Gan. "Do me the honor to take these morsels to his shop as you go down the street, and tell him I am coming to see him within an hour."

Lao Fung received the messenger with a scowl, but he accepted the whole of the gift, and sent word that Gan should come at once, if he chose.

The smith and the storekeeper had never been very friendly, but there had been no quarrel, and as the old man knew nothing of the scene which had just passed in the kitchen, he had no pretext for declining to see his caller.

Gan hastened down to the store. As usual Fung was counting his cash, but this

time it was a light task, as his sales had been small. He put his rushlight on his counter, admitted the young man through the shutters, and replaced the board he had taken down. The unsteady flame, little more than a spark, illuminated only a small part of the room. The time-blackened walls and dusty shelves which Gan knew to be there were invisible. Invisible, too, were the door into the courtyard and the curtain which separated the shop from an inner room.

Gan's purpose was to endeavor to surprise the old man into some sort of admission of guilt in the matter of the stolen skin, but he had not succeeded in planning a method. He must trust to chance for a favorable moment.

They seated themselves, and Fung began with profuse thanks for the titbits the young man had sent.

"It is nothing, a mere trifle," answered Gan. "I did not even kill the beast myself."

"Indeed," rejoined Fung. "I heard that you had ascended the sacred heights to hunt."

"That's true, but I returned empty-handed. While I was away the spirits told me that some of the village folk were in difficulty. Tell me about that."

Fung started and flushed, and by his undisguised scowl it was evident that this subject was distasteful to him. He disregarded the request, and pretended to be interested in hunting.

"The villagers say you are the best hunter among them, and that you know where to look for the game in winter and in summer. These great wild goats live high up, where the bamboo grass grows, do they not? But tell me, where do the small goats live?"

"They inhabit the rocks and bushes lower down," answered the smith. "At night they seek shelter at the base of the precipices. The deer live lower still, even in the grassy hills. Your slave girl sees them when she goes for fuel. Now say, Lao Fung, why you have accused the girl falsely of theft."

Fung recognized an enemy now, and anger almost got the better of him. He started to rise; the rushlight, fanned by his motion, burned a little brighter, and Gan caught a momentary glimpse of a face in the doorway. It was the face of a strange man, a dissipated, evil face, and one not to be forgotten.

Gan felt that his end had been accomplished with unexpected ease. He had probed the man he suspected, and had seen him lose his composure twice. The smith prepared to depart and said, "As I see you have a guest in the house, I will hasten away."

At this thrust the old man instantly glanced over his shoulder at the door, but he said, "There is no guest. You are mistaken."

Gan paid no heed, but took down the shutter himself, and with a bow, disappeared up the street. As he went home he said to himself:

"By my mother, the old rascal is guilty of the theft, and the girl is innocent, yet justice will not be done. When did that corrupt old mandarin ever do justice? The girl will lie in prison for months before she gets a trial, and then, of course, she will be clapped in a dungeon and forgotten. But this must not be. Money would quickly buy her liberty, but how is a poor smith to find so much silver? I wonder who the ugly face belongs to? Why was the fellow listening, and why is Fung ashamed of his guest?" He lay restless the greater part of the night, revolving these perplexities.

Shan-liang stood at the inn door as usual when Gan came to him in the morning.

"The soldiers are here," said the innkeeper. "They came last night."

"That's evil news, but we cannot hinder them," answered the young man.

"The lazy fellows are not up yet," continued Shan-Liang, "but you won't have long to wait if you want to speak with them."

"I came to speak with you," replied Gan. "I am going on a long journey soon, honorable Shan-liang. While I am absent I turn my shop over to your management."

"But why do you leave the village?" asked the old man. "Are you going back to the abode of your ancestors?"

"No, not there, but—"

His sentence was not finished, for the noisy soldiers came into the room demanding their breakfast. Gan sat watching the slovenly fellows in their tattered and dirty red jackets with black characters on front and back. He did not like the looks of their faces, for they were low ruffians, limited in their evil deeds only by their cowardice. As they ate they talked loudly about the girl they were to arrest, and some made jokes at her expense till Gan grew angry and left the inn.

He went to his house and took his small store of savings from its hiding place. There were but a few ounces of silver in the shape of small, irregular lumps. When he returned to the inn the soldiers had already gone down to the house of Fung.

Gan followed, and on his way bought a large piece of unleavened bread in which he secreted a number of his lumps of silver. The ruffianly soldiers had brought Ma-wu out into the street, and one was holding her by a heavy chain bound round her waist. Blinded by tears, and weak from fright, the poor girl stumbled about as the fellow pulled her from side to side.

Most of the villagers were gathered there. Some jeered and cursed at the soldiers, some spoke kindly to the unfortunate prisoner, but none offered to accompany her to the city, till Gan said:

"Mothers of Ling-tai-miao, why does not one of you go with this maid? Though she be but a slave in name, her father is as worthy a farmer as the husband of any one of you."

Just as he said this, Ming-ta, the innkeeper's wife, came up. She had heard his reproving words, and replied:

"Unselfish Gan, I have made preparations to go. I see I have come just in time."

As they started off down the stony stream bank women wept and shrieked, and men called imprecations after the soldiers, who paid no heed, for they were well used to such scenes.

Gan followed a little way, and when they were free of the crowd he handed the bread to Ma-wu with the caution that she should save it till her arrival, and eat it slowly. He did not tell her of the silver lest the soldiers should overhear.

"Tomorrow I start on a long journey," Gan announced, "But by the second dark of the moon I shall be back. Keep courage, Ma-wu; your innocence is plain to see, and you shall soon be set free." Then facing the leader of the soldiers he said, "Do not hurry the girl so fast over the rough trail. If you must imprison her, put her in a clean cell away from other prisoners, and I will make you a present." With that he handed the fellow a string of cash, almost the last of his savings, and saying a kind word of farewell to the slave, stood till her pathetic figure had vanished around the turn.

Sadder than he had ever felt before, he returned home, now firmly resolved on his course. As he passed up the street Fung stood in his shop alone, with a black look on his face. He had saved himself from the foul prison, but he had lost a dutiful servant, and he was not happy.

III

The soldiers reached the city with their prisoner after night had come. Extremely tired, and with wet feet and muddy clothing, Ma-wu was at once locked in a low cell, without a light, and without furniture. The forlorn girl sat upon the cold brick floor and cried softly, till Ming-ta, who had remained in the street, found her way to the bars that faced the courtyard.

"Innocent Ma-wu, be comforted," she said. "See, I have brought you a good soft matting of straw to lay on the sleeping-platform, a dogskin for warmth, and a quilt to cover yourself. Eat the bread you have tonight, and tomorrow I will bring you millet gruel."

The girl now calmed herself, and undoing the loaf from the sling in which it still hung on her back, began to eat the dry bread. Presently one of the lumps of silver fell on the floor with a little ring. She groped for it, weighed it on her finger as she had seen her master do, and realizing what it was, saw that Gan had actually made an endeavor to help her. One by one the other pieces appeared, until she had a little heap in her lap. It was enough to keep her in food for a long time, if she did not get too badly cheated in exchanging the silver for cash.

Ma-wu began to think of Gan very tenderly. He was a good man to help a poor girl, and so very kind. Why had her older brother not come to her aid in some way? She did not know how nearly her family had forgotten her.

After her food she was somewhat comforted, and began to feel the need of rest, so she groped about in the darkness till she found the sleeping-platform, spread over it the thick straw mat, laid on this the dogskin, and drawing the quilt over her, slept.

To Ma-wu the night passed as if it were but one minute. She awoke to find the kind Ming-ta at her window bars again.

"Ma-wu, here is your gruel," said that good person. "Take it now while it is hot. I have brought this worthy woman to see you. It was at her hut I spent the night.

She is the honorable mother of many sons. You may trust her, and she will take charge of you, for you know I must return to the village."

"Benevolent Ming-ta, you have been as much as a mother to me in my trouble. I grieve to have you leave me, but you must no longer wait on the insignificant slave of your neighbor." Then she spoke to the other woman, "Kind mother, what shall I call you?"

"My name is Hwa-na, and you may call me so, if you like."

"Good Hwa-na," continued the girl, "can you come daily and bring me food? I have silver to pay you with."

It was arranged that Hwa-na should come every morning, bringing gruel and macaroni, and a little boiled pork and salted turnip. Ma-wu parted with her smallest lump of silver to pay for this food.

When Ming-ta had departed a great loneliness came over the girl, and this lasted for days. The old woman was but little comfort, and lacked the kindness of the mountain villagers. When, after some time, the first piece of silver was spent, Hwa-na came to the bars empty-handed, and complainingly asked for more. Then, before the girl could produce another lump, she added that without money no more food could be provided.

Yet there was consolation in the old woman's visits, for she sometimes brought little items of news. One time she came with the information that Gan had disappeared from Ling-tai-miao, and that all the villagers were wondering.

Ma-wu thought, "He has gone secretly on his journey," but she said nothing to the old dame about this.

Day by day and week by week the slave girl sat in the corner of her gray cell, and looked through the bars at the soldiers and the civilians coming and going through the courtyard.

During this time changes took place in the yamen. The old official received orders from Pekin to move to a distant city. A much younger and more energetic man took his place, and being a Chinaman of more than ordinary sincerity and goodness, he was anxious to make a favorable impression on his people. Therefore he commenced soon to hold court and dispense justice among the many prisoners his predecessor had allowed to collect. Some were striped with the bamboo, some were sentenced to long imprisonment, and one or two highwaymen were sent to the provincial capital for execution. Not a few were set free, as already having served a sufficient time while awaiting trial.

So in time the turn of Ma-wu came.

When the slave girl was brought in by her guard the long trial hall was vacant, except for a few soldiers and servants. After a tedious wait, during which Ma-wu trembled with fear and excitement in spite of her desire for self-control, the mandarin entered. He was a shrewd-faced little man in a long purple gown adorned on breast and back with two gold-embroidered pelicans, insignia of rank. His cap was tipped with a purple button. Seating himself at the table which stood opposite the door, he eyed the servants critically. Then he noticed Ma-wu, pale and weak from fright and her long imprisonment. It was so unusual to see a young girl prisoner, that he looked again, and his attention was turned to the business of the day sooner than it might otherwise have been.

"Is this the woman charged with the theft of a leopard skin from a high mandarin?" he asked an attendant.

"It is, Excellency."

"Where are the witnesses? We will proceed."

"There are but two, Excellency. They are entering now."

Lao Fung came in and bowed before the mandarin. His wife, the fat Lu, who followed closely at his heels, did the same. The judge did not return their salutation, but looking sternly at Fung, said:

"Tell me about this theft."

Fung recited in many words how the official had been detained at Ling-tai-miao, and how the robe had been missing the following morning. There was no evidence that anyone had broken in or climbed the wall, so the slave girl was the only one who could be guilty.

Lu gave evidence to the same effect.

The prisoner was called on to speak for herself, but she could do no more than falter a protestation of innocence. Shan-liang and Ming ta were there, but though convinced that the girl was not guilty, they had no defense for her.

The mandarin was unsatisfied with the case, and said, "The evidence against the girl is weak, but as no one appears in her

defense, the law requires me to imprison her as a suspect. Witnesses, you may go. Soldiers, remove the prisoner."

The court was adjourned, and the mandarin was about to leave the room when there came the thunder of a deep-toned gong close by.

All started in wonder, and the magistrate stood half annoyed, half expectant, while soldiers ran to stop the intrusion.

It was the gong before the yamen gate, hung there to signify that he who rings may obtain immediate justice, but not for decades had its tone been heard. The instrument had become but a symbol.

The soldiers returned saying, "Excellency, two men stand at the gate, one a prisoner, bound and helpless, the other a strong man who throws us all off, rings, and demands a hearing."

"Admit them both!" cried the judge. "Here justice shall be done as of old."

Then the ringing ceased and there entered Gan, pushing before him a ragged, evil-looking man with hands bound and feet hobbled. Gan glanced at Ma-wu with his cheerful smile. She had sunk to the floor, but on her face was a look of happiness and hope, which it was good to see.

The smith bowed to the magistrate, and to the company; then seeing that he was expected to speak, he addressed the judge:

"Benevolent Excellency, you may well wonder what brings a base smith to intrude on your court in this way. Pursued by the companions of this man in ropes, I was in great haste to gain entrance, but I did not know that my arrival would be so timely. See, I have captured the man who knows all about the leopard skin."

He removed the bandage from the eyes of his prisoner, and turned the man's face first toward the judge, then toward Fung. The brow of Fung grew troubled.

"Stout smith," said the magistrate, "we listen; explain your meaning."

"Illustrious Judge," continued Gan, "I am the smith of Ling-tai-miao. Like all the villagers, I knew this girl was innocent, and I resolved to ransom her with money. Therefore I went on a long trading journey into distant provinces, and on my return I stopped one night at the town of Pau-chong. There in the inn I overheard this man telling with laughter how Lao Fung had sold him the leopard skin that had been stolen. I recognized his face, for I saw him once at the house of Fung. That night I slept near him and watched, and in the morning I overcame and bound him."

Pointing suddenly at Fung he exclaimed, "There is the real thief! This wretch in the ropes is the King of the Robbers of your own city!"

Gan had spoken with such directness and vehemence that his words convinced his hearers at once.

"Imprison this Fung!" shouted the judge. "Put him in a wooden collar, and make it tight about his throat. Soldiers, you must know this miserable man whom the smith has brought. Is he the King of Thieves? Answer me!"

Reluctantly a spokesman of the soldiers admitted that he knew the chief of thieves, and that this man was he.

"Then put him in a dungeon!" commanded the magistrate. "I will sentence him tomorrow."

The two prisoners were hurried away, and the official, turning to Ma-wu, said:

"Young woman, you are free to go. The smith has saved you many a day in prison.

"Stout and honest smith, your capture of the thieving beggar is worthy of reward. If you wish to enter my service you shall keep my mules shod, and the guns of the troops in repair."

"Great Man," answered Gan, "I sun myself in your benevolence, but I am of the mountains and the forest, and the gray walls of the city are hideous to me. Therefore I cannot take your offer. But if you wish to favor me, give this maiden freedom from her bondage to Fung. She has served him well for years, and her work has paid the debt her father owed, thrice over."

A few strokes of the official pen gave Ma-wu her freedom, and the two left the yamen in happiness.

The exonerated maiden was received with kindness in the village, and was taken to the house of Ming-ta.

One morning before many days had passed, she left the inn clad in a gown of crimson, and seated in a palanquin all decked with crimson cloth. Her four chair-bearers came to a stop close to the smithy door, and the bride slipped out into her new home, amid the sound of loud music and the applause of the villagers, who had gathered to the feast.

The Needed Art Galleries for New York

By HOWARD RUSSELL BUTLER[1]

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THE forces of creative art of any country naturally concentrate in its largest and most active metropolis. It is there that the organizations of workers in all the branches of art can best come together and unite their efforts. Individual artists may well pursue their calling in any part of the country, but they must keep in touch with the art center.

In this way the city of New York has undeniably served as a center for the art activities of the entire country. It is said that the first art school was founded in New York by Archibald Robertson about 1792. The New York Academy of the Fine Arts was proposed in 1802 and incorporated under the name of The American Academy of Fine Arts in 1808. The New York Drawing Association was founded in 1825—the National Academy of Design growing out of it in 1826. There have since been organized the American Water Color Association, in 1866; the New York chapter of the American Institute of Architects, in 1867; the Architectural League of New York, in 1881; the New York Water Color Club, in 1890; the National Sculpture Society, in 1893; the National Society of Mural Painters, in 1895; the Society of Illustrators, in 1902; and many others.

These organizations have their headquarters in New York City, but their membership is drawn from all parts of the country. That of the National Academy of Design is scattered through more than thirty states and about ten foreign countries. These organizations are almost exclusively of professional workers. From their membership has come and is coming the major part of the original work in the fine arts of this country. Whenever an important exhibition takes place in the eastern, southern, or western section of the United States, the works displayed are very largely drawn from the art organizations of New York City. Thus the exhibitions of Pittsburgh, Chicago, Philadelphia, and St. Louis have counted largely on work by the members of the New York societies. Frequently from forty to sixty per cent of the paintings in these exhibitions are executed by members of the National Academy of Design.

In the smaller cities the art schools, the art museums, and the exhibitions of current art are generally combined in one movement and housed in a single building. But in the main art centers these divisions are so important in themselves, that they may better exist as independent movements.

The vital, living art of a country is one thing, and the collecting of the art of the past another. The art patron therefore has open before him two channels. He can directly aid the art of his own country by stimulating the best production of living artists and encouraging their exhibitions; or he can bring together permanent exhibitions of ancient and foreign and past domestic art in the galleries of a museum. Both lines offer effective aid in awakening an interest in good art throughout the country.

Of late the museums have enjoyed great prosperity, and their phenomenal growth has done much to establish standards of excellence, *indirectly* benefiting native art. But far less attention has been given *directly* to native art. It has not only lacked patronage, but it has lacked the facilities of exhibition, and has had to get along as best it could, so that the fight for bare existence has proved long and tedious. The struggle of the National Academy of Design for a home, ever since it was obliged to leave its old location at Twenty-third

[1] Artist of "The Solar Corona," a canvas showing the total eclipse of the sun of June 8, 1918, presented to the American Museum by Mr. Edward D. Adams and now on permanent exhibition in the west assembly hall of the Museum building. Mr. Butler is known to readers of NATURAL HISTORY through his article on "Painting the Solar Corona," published in the March number (pp. 264-271), 1919.

Street and Fourth Avenue in 1896, has thus far been a discouraging one. For more than twenty years it has held its annual exhibitions in the Fifty-seventh Street building. It has been compelled to hold two exhibitions each year because of the limited space, and yet the walls have had to be unduly crowded. Many able artists have hesitated to have their works seen under such conditions, and so the exhibitions have suffered in quality. The destruction by fire of these galleries last January again brings this important question to the front. Not only the National Academy, but all the other art societies of the city, are calling for adequate quarters and exhibition spaces. This mutual desire has led to the formation of the National Academy Association, a union of ten societies, headed by the Academy, and having for its one great object the erection in this city of a handsome edifice which shall be both an ornament to the city and a home for all the forces of native art. But thus far the efforts to secure this building have been fruitless, and the anomalous condition exists today that the city which is the center of the creative art of the country has no sufficient place from which the influence of that art can radiate.

A great exhibition building, with permanent quarters for these organizations, and adequate galleries in which displays can be made of the annual output of the studios, such as appear in the Salons of Paris and the galleries of the Royal Academy of London, is needed. The city has a right to be proud of its commanding position in the realm of creative art. Why, then, should there not be a movement to crystallize that position and give it a proper setting, so that New York may be acknowledged by the entire country as the home of native art, just as the entire country now thinks of it as the home of the great Metropolitan Museum?

It seems to me that here is an opportunity which might be welcomed by one or more enlightened citizens who realize the value of living art and the services of the living artist to the community, to come forward and provide the needed building,—a home center of American art,—thus at once encouraging the artist, enriching the city, and erecting to his or their own fame an enduring monument.

A small section (somewhat to the right of the middle) of a copyrighted sketch for an Indian mural by Mr. Will S. Taylor. This is a panel twelve by sixty feet, designed for the north wall of the North Pacific Hall of the American Museum, which will take its place between a series of eight murals on the west wall showing industries and eight on the east showing ceremonial life. The panel presents the Indians of southern British Columbia at play—those at the left are gambling with a sort of "Button! Button! Who's got the button?" game, while the man in the foreground at the right has just thrown his spear through a hoop

Without the Aid of Eyesight

It is with the permission of Author and of publishers, Henry Holt & Company, that we give the following brief quotations from *Hitting the Dark Trail*, by Clarence Hawkes

"THEN little by little the meaning of all my years of blindness was made plain to me. If I had always retained my sight, I should have gone on . . . learning of nature from reading her great book without ever stopping to think what the things that I saw meant. I must have gone on hunting and trapping, fishing and camping, without ever having gathered together or arranged my knowledge.

"This then was my way out. I had lost my eyesight in the deep woods, with a gun in my hand, in the very hour of despoiling nature. I would turn about and tell the American boys and girls all these intensely interesting things . . . I would show them the life of field and forest from the side of the hunted. I would try to get the attitude of all my little furred and feathered friends, and put it into books. I would teach children not only to know and love the birds and squirrels, but also to care for them, and to help them in their unequal struggle. . . .

"Living as I do in a country village, with the world of nature all about me, I am still able to do much very effective nature study, and to gather a few interesting facts each year. My home faces upon the broadest and most beautiful street in the world, which is flanked by four rows of enormous elms. From that happy day in March when the first bluebird perches upon the tiptop branch of one of these trees and greets me with his sweet little 'Cheerily,' until he flies away in the Autumn, one of the last of the song birds to leave, this wonderful street is an aviary of no mean order. I am able each year without going out of my street to identify more than fifty species of birds. At the back of my house is a small orchard which is a favorite nesting place of the birds, and here I discover a few more species that do not ordinarily frequent the street. In company with some one who has good eyes, with an opera glass and a bird book, I pass many happy hours while the silver-footed moments of Summertime go by. . . .

"It would surprise one of the uninitiated to know how much I can observe of the out-of-doors, either in field or forest, or on lakes and streams, wholly by myself without the aid of eyes. My hearing for the slight sounds of nature is so keen, and my senses are so quick to detect new clues either by sound or scent, that I am just as apt to discover the new and wonderful things as are my seeing friends who accompany me. In the Spring I hear more wild geese go over than does any one else in the vicinity, because my ears are unconsciously keyed to catch their stirring water slogan. To the trained ear every rustle and every snapping twig in the forest means something, and all these slight sounds tell their own story.

"I would not need to ask anyone to identify many of these sounds for me. The steady trot, trot, trot, of a fox is no more like the uneven hopping of a rabbit than the galloping of a horse is like his trot. A bird and squirrel never rustle the leaves of a tree in the same way. The scratching of small squirrel feet down the bark of a tree is as unlike the similar slight sound made by a woodpecker traveling up the bark as can be imagined.

"The bird language also I probably understand much better than a man with sight ever could, for all the little intonations are so clear to me. Happiness, fear and alarm, querulousness, good spirits or pain, all are conveyed by my little friends in a language as plain as the spoken word. Only it takes the ear to hear, and the heart to understand these things."

Courtesy of Ernest Harold Baynes

During the hard winter even sturdy blue jays appreciated the friendliness of their human neighbors

Aquatic Preserves

By A. S. PEARSE and CLYDE B. TERRELL[1]

ONLY during the last few years have sportsmen and those interested commercially in aquatic resources come to realize that results from water crops depend on intelligent planting and care just as much as from crops raised on land. A hundred years ago the United States was rich in game, fish, and fowl. Herds of bison roamed over the western prairies; elk and beaver were being killed and trapped in the suburbs of Chicago by the Indians. Nobody spoke of conserving anything. A hundred years hence there will be no "wild" country except in deserts and national parks. The advance of civilization gives increasing interest to preserves for all those who love animals.

The vegetation is the dominant factor in any aquatic preserve. It furnishes food for birds, fishes, and other animals. Without this fundamental resource the game will not be present. Moose like to stand shoulder deep and feed on succulent water plants; ducks dive for the luscious wild celery—the recent work of McAtee shows that wild ducks feed on a wide variety of aquatic plants; in Wisconsin more than 20 per cent of the sunfish's food consists of aquatic vegetation. In addition to such direct contributions to the food resources of wild animals, the aquatic plants do a still greater service by supporting a host of small vegetable eaters, such as insect larvæ, crustaceans, and snails. These are eagerly sought by many animals which feed in the water. Water plants also furnish shelter for many animals—particularly for immature forms.

Several years ago the junior author of this article began a study of aquatic preserves with the purpose of learning how to make attractive, natural homes for fishes and birds. This work has been continued with increasing success and patronage up to the present time—the clients being found mostly among game clubs, owners of large estates, and conservation commissions. It has been necessary to study the stomach contents of fishes and birds at various seasons of the year; to spend long hours in the field trying to discover just what makes certain habitats more "attractive" than others; to glean from the literature on the subject hints which would help to make the work a success. Many mistakes have been made and some phases of the work are still far from satisfying, but—we have learned! At present a permanent staff of employees is maintained. The men collect aquatic plants in the open season and are kept busy trapping in the winter.

Wild duck's nest on a planted game preserve, Oconomowoc, Wisconsin.—As wild life is more and more restricted to limited areas with the increasing settlement of the country, the scientific care of public and private preserves becomes of the utmost importance. In the case of waterfowl and game fish, and even of many of the larger mammals, the pond and stream vegetation is a paramount factor in their conservation, for it is from the aquatic plants that directly or indirectly they gain their food

[1] The senior author, Dr. A. S. Pearse, is associate professor of zoölogy at the University of Wisconsin; the junior author, Mr. Clyde B. Terrell of Oshkosh, Wisconsin, who took the photographs used in this article, is a specialist on the development of attractive places for birds, game, and fish.

At first the keeping and transporting of the propagative material caused us trouble. Wild rice seed gives its highest germination test if kept damp, and will not grow at all if allowed to become entirely dry. The seeds of most aquatic plants will not keep indoors in bins as do ordinary farm and garden seeds, but will do best if stored in bags beneath the ice in a lake or stream—where they must of course be kept below frost. They will also keep well if placed in loosely filled, wet sacks, laid flat on cakes of ice, and covered with damp sawdust. A foot of sawdust is sufficient to keep the seed cool in hot weather and four feet will prevent it from freezing during the winter. The list given below states the particular value of each plant and the proper time for planting.[1]

The problem presented for solution by the owner of a preserve is usually the increase of production—of fishes, of wild fowl, or of both. Fortunately the general principles involved in providing attractive homes for fishes and waterfowl are much the same. We believe that it consists primarily in providing an abundance and variety of aquatic vegetation. This view has been supported by extensive plantings in Michigan, Tennessee, Texas, New York, and other localities. Recently in Wisconsin the Chippewa River was dammed, and Lake Wissota, a beautiful body of water fifteen miles long, came into being. This lake by the judicious use of the proper aquatic plants has been advanced several years ahead of what it would be if succession had been left to "nature." Fishes have increased in numbers rapidly and ducks are becoming more abundant.

In putting out aquatic crops one must exercise as much care as would be taken when sowing seeds on land. Wild rice will not do well in a landlocked lake. It requires some current or change of water, but does best in sheltered bays or sloughs where the plants are not disturbed by swift currents or the wash of waves. If plantings

[1] THE PLANT—Its Value	Where to Plant	What to Plant	When to Plant: No. U.S. & Canada	When to Plant: So. U.S.
Wild Celery (*Vallisneria spiralis*)—Unfailing attraction for canvasbacks, redheads, bluebills. Best fishing where it grows, provides food, shelter, keeps water fresh and clear insuring more fish reaching maturity. Submerged.	1½ to 12 ft. fresh or slightly brackish water. Sand, loam or mud soil. Soft rich soil and 2 to 7 ft. water best	Winter buds-Tubers	March 1—June 25	
		Plants	May 15—July 25	May 15—Aug. 10
		Seeds	Sept. 15—Nov. 1	
Duck Potato or Wapato (*Sagittaria latifolia*)—Exceptionally attractive to practically all varieties of waterfowl. Handsome decorative plant. Dark green arrow-shaped leaves, white and yellow flowers. Grows rapidly.	Shallow waters, 1 inch to 18 inches deep; marshy muddy spots	Tubers or Plants	Mar. 15—July 15	Feb. 15—Aug. 1
Wild Rice (*Zizania aquatica*)—Exceptionally fine attraction for mallards, teal, pintails, black duck, geese, etc. Forms attractive clumps and backgrounds for water gardens. Early giant variety best.	Sheltered waters, not salty to taste, ½ to 3 feet deep with visible outlet. Prefers rich soft soil	Seeds	Sept. 15—June 15 When not frozen	
		Plants	Apr. 15—June 15	
Sago Pond Plant (*Potamogeton pectinatus*)—Submerged plant. Seed size of wheat. Tubers and tender vegetation attract practically all wild ducks, especially teal. Food and shelter for fish.	1 to 6 feet fresh or brackish water	Tubers and Roots	Apr. 1—July 1	Feb. 1—July 15
		Seeds	Aug. 15 to Nov. 1	
Broadleaf Pond Plant (*Potamogeton natans*)—Good for fish ponds. Desirable wild fowl attraction. Submerged.	1 to 8 feet fresh water. Fairly rich bottom	Roots	Apr. 1—July 15	
Brownleaf Pond Plant (*Potamogeton crispus*)—Floating leaf. Attracts black duck, mallards, teal, etc. Fish usually found around it.	Fresh or brackish water. 1 to 4½ feet deep	Roots	Apr. 15—July 15	
		Seeds	Aug. 15—Nov. 1	
Duckmeat (*Lemna*)—Attracts both wild ducks and fish. Floats, not attached by roots, therefore will grow over either poor or rich bottom.	Small ponds, ditches or bays where practically no waves	Plants Submerged Variety	May 1—Aug. 10	May 1—Sept. 1
		Plants Floating Variety	May 15—Aug. 10	May 15—Sept. 1
Bulrush (*Scirpus*)—Cover and food for waterfowl. Backgrounds or clumps for water gardens.	Fresh water; 1 to 4 feet deep. Grows on rich or sandy soil	Roots	Apr. 1—July 15	Apr. 1—Aug. 1
Wild Duck Millet (*Echinochloa crus-galli*)—Food and cover for domesticated and wild waterfowl, quail and other birds. Desirable background.	Land around edge of water. Land out of water in summer	Seeds	Apr. 1—June 20	Mar. 1—Aug. 1.
Water Milfoil (*Myriophyllum*)—Excellent plant for fish ponds and aquariums. Attracts many waterfowl.	Quiet ponds, streams, fairly rich soil, 1 to 4 feet fresh water	Plants	Apr. 15—July 15	

(Continued on opposite page)

are made at the mouth of a stream, the spread against the current will be very slow, but those toward the headwaters will soon propagate downstream. Proper bottom is of course necessary, and wild rice does best in soft dark mud. Seeds or tubers are more likely to become established if not planted among a dense growth of other vegetation, which, like weeds in a garden, may choke out the plantings. When it is desired to make plantings in places where there is thick vegetation, it is best to rake out spots in which to sow the seeds. The surrounding growth will protect the planting from waves, swift currents, and the depredations of animals. A variety of aquatic plants is desirable in a preserve, because the season of production and of "attractiveness" for fish and fowl is prolonged.

A game preserve in the eastern United States, showing planted pickerel weed, water lilies, and sedges.—To understand just what will make a habitat most attractive to the desired wild visitors requires extensive study of their food habits, of the vegetation which will successfully flourish on a given pond bottom, and of the enemies from which both the plants and animals must be protected

Plants must often be given protection for a time after they are put out. Cattle or deer may devour an entire planting before it has had a chance to become established. The carp, which fishermen have well named the "water hog," may root over an area of bottom, devouring seedlings in great numbers. Muskrats and snapping turtles cut off and destroy wild celery. It is usually de-

COONTAIL (*Ceratophyllum demersum*)—Desirable submerged plant for waterfowl and fish.	Still waters; floating plant; will grow over either rich or poor soil	Plants	June 1—Sept. 1 | June 1—Sept. 15
ELODEA (*Anacharis*)—Submerged plant. Especially good for fish ponds, aquariums, domesticated and wild waterfowl. Rapid grower.	Fresh water ponds, streams or bays. 1 to 8 feet deep. Quiet or slow current	Plants	May 1—Aug. 1 | May 1—Sept. 1
MUSKGRASS (*Chara*)—Attracts wild ducks. Recommended for fish ponds.	Fresh or slightly brackish water containing lime (indicated by shells)	Plants (with oögonia)	May 1—Oct. 15
PICKEREL WEED (*Pontederia*)—Duck food. A handsome ornamental plant. Purple flowers.	Shallow fresh water, 1 to 3 feet deep; fairly rich soil	Roots or Plants	May 1—July 1
WATER CRESS (*Radicula nasturtium-aquaticum*)—Duck food. Green all winter in unfrozen streams. Salads. Ornamental.	Shallow streams, springs, fountains. 1 to 8 in. water remaining open in winter	Plants	Mar. 1—Aug. 15 | Mar. 1—Oct. 15
WIDGEON GRASS (*Ruppia maritima*)—Submerged wild duck food.	Slightly brackish or saline water. 1 to 5 feet deep	Roots or Plants	May June
EEL GRASS (*Zostera marina*)—Good duck and brant attraction for salt water.	Shallow salt water, bays, etc.	Roots or Plants	Apr. 1—Aug. 1
WATER LILIES—Attract waterfowl. Provide food and shelter for fish. Ornamental. Handsome flowers.	Tubers and Plants 1 to 5 feet quiet, warm fresh water. Fairly rich soil	Tubers or Plants all varieties	Apr. 15—July 1 | Mar. 1—Aug. 1
American Lotus (*Nelumbo lutea*). White (*Nymphæa odorata*). Yellow (*Nuphar advena*). Banana (*Castalia mexicana*).	Seeds 1 to 3 feet deep	Seeds Amer. Lotus Yellow	Apr. 15—July 1 | Mar. 1—Aug. 1 Start earlier inside and transplant
			Aug. 15—Oct. 1
CANES, QUILLWORT (*Arundo donax*)—Provide cover and shelter. Grow 5 to 8 ft. high. Clumps look well in water gardens.	½ to 2 feet, fresh water	Roots	Apr. 1—July 1

The wapato, or duck potato (*Sagittaria latifolia*), is an ornamental plant which grows rapidly wherever introduced. It is a favorite food of wild ducks and of muskrats

sirable to make large plantings in several places in a tract. This increases the chance that the crop will become established. Large browsing animals and carp may be kept away from a small bed by using wire netting. Carp may be kept down by draining or seining. Muskrats and turtles can be trapped.

Although vegetation is the matter of chief importance in establishing and maintaining a preserve, there are other factors which are essential. There must be some good rich bottom "soil" and some bare bottom. For most fishes and for all ducks the fauna of the bottom mud and the aquatic vegetation is a much more important source of food than that furnished by the plankton (the small organisms swimming in the water itself). Plant growths in themselves enrich the bottom after a time, but in small ponds it is sometimes well to use fertilizers. In Germany and China the yield of fishes from a small pond has been increased by adding manure.

We are loath to admit it, but there may be too much vegetation. The fishes which do best in weed-choked ponds and swamps are the mud minnow, stickleback, and bullhead—all of little value to man. The best game fishes cruise along the borderline between the shore vegetation and open water. Many of our most desirable fishes require bare bottom for spawning. These facts and others make it safe to say that it is wise to have some bare bottom and some open water in any preserve. Sandy or stony "bars" are particularly useful, and in a pond may be introduced artificially by hauling a few loads from a gravel pit.

In a small body of water where fish or ducks of the same species are kept year after year, the stock may become infected with parasites to such an extent as to be of no value. There are small lakes in New York where most of the worth-while fishes are "grubby." A trout hatchery in Wisconsin which has almost ideal physical conditions (pure spring water and fine stream bed) is of little value because it is infested with enormous numbers of parasitic crustaceans which kill the trout by attacking their gills. In order to prevent a too abundant growth of aquatic vegetation and lessen danger from parasites, many hatcheries "rotate" their ponds. In regular order they are drained and allowed to lie idle over winter, so that they may "freeze out."

One final point in regard to restricted fishing in preserves. Many times people wonder why the fishing is "not what it used to be when I was a boy," although fishing has always been limited strictly to "sportsmen's methods." Angling, if practiced alone, will cause the game fishes to decrease and allow others to increase disproportionately. A body of water can support only a certain number of fishes. To keep a balance between the species it is usually desirable to allow supervised seining or fishing by other means to keep down fishes like the carp, sucker, dogfish, and gar, which seldom take a hook.

Scientific Zoölogical Publications of the American Museum

SUMMARY OF WORK ON WHALES

By FRANK E. LUTZ

ONE of the most curious of whales is the pygmy sperm whale, *Kogia breviceps*. Although very rare in this part of the world, a large individual of this species became stranded a year or so ago at Long Beach, Long Island, and its skeleton was soon after added to the great collection of cetacean material which Mr. Roy C. Andrews has made for this Museum. The specimen was a female and very fortunately contained a full-grown fœtus which was preserved in alcohol for future study. When whales are launched into the world they are almost like small models of their gigantic parents; so here was an opportunity for some intensive studies of the anatomy of this animal, studies which could be carried out far more effectively on a fœtus forty-four inches long than on an adult carcass of many tons' weight. The fœtal specimen was accordingly intrusted to Prof. H. von W. Schulte, then of the department of anatomy, Columbia University, and his associates, who are coöperating with Mr. Andrews in a series of studies on cetacean anatomy.

Adaptation and Construction in Whales

Out of the great mass of special observations recorded in a paper[1] by Dr. Schulte and Dr. M. de Forest Smith, of the College of Physicians and Surgeons, Columbia University, we may select for present notice only a few of the more general facts, such as exemplify the marvelous construction of whales, a construction which enables these highly transformed descendants of land-living mammals to move in the ocean with great power, endurance, and speed, and even to descend to surprising depths.

Concerning the *panniculus*, or outer mantle of muscle covering the fore part of the body, the anatomists conclude that its great development serves not so much in moving the flipper as in maintaining pressure upon the body cavities so as to prevent their distension by air pressure from within when the animal rises from deep water.

Beneath the *panniculus* was found, as in other whales, an arrangement of the musculature of the fore limb which is a special modification of the normal mammalian type, as shown in the accompanying figure. But adaptation for swimming and diving has progressed so far that certain of the normal muscles of the fore limb (such as the biceps, the pronators and the supinators) have been lost or much reduced, while others, such as the deltoids and the extensors and flexors of the hand, have been greatly increased.

The tail being the principal organ of locomotion, the musculature of this region is much developed, especially along the high spines of the backbone. The strong muscles of the under side of the body play an important part in regulating the pressure of the water against the viscera in diving.

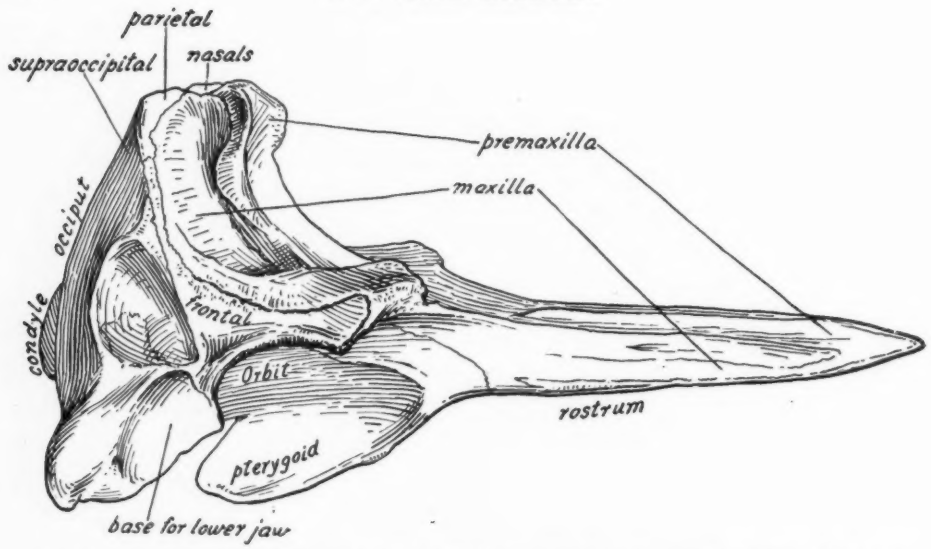
So thoroughly has adaptation impressed itself upon construction that the arrangement of the spinal nerves and their numerous branches loses much of its normal mammalian intricacy and, especially toward the rear of the body, takes on a secondarily simplified segmental pattern which is superficially suggestive of the arrangement of these nerves in fishes.

On the Anatomy of the Pygmy Whale

A paper[2] by Dr. J. D. Kernan, department of anatomy, Columbia University, and Dr. H. von W. Schulte is partly a confirmation and extension of the accounts of Benham and le Danois of the anatomy of *Kogia*, their material, however, being adult, while Doctors Kernan and Schulte deal with the fœtal specimen already mentioned. After considering the form and function of the many curious organs of the respiratory tract and viscera, the authors conclude their

[1] Schulte, H. von W., and Smith, M. de Forest. 1918. The External Characters, Skeletal Muscles, and Peripheral Nerves of *Kogia breviceps* (Blainville). *Bull. Amer. Mus. Nat. Hist.*, XXXVIII, Art. 2, pp. 7–72. [Review furnished by Dr. William K. Gregory.]

[2] Kernan, J. D., Jr., and Schulte, H. von W. 1918. Memoranda upon the Anatomy of the Respiratory Tract, Foregut, and Thoracic Viscera of a Fœtal *Kogia breviceps*. *Bull. Amer. Mus. Nat. Hist.*, XXXVIII, Art. 8, pp. 231–67. [Review furnished by Dr. William K. Gregory.]



Side view of the skull of Cuvier's whale (*Ziphius cavirostris*), showing some remarkable structural adaptations to resist the pressure of the water and the twists and strains upon the prolonged rostrum, caused by the powerful forward thrust of the body in swimming and diving. The back part of the skull (occiput) forms a wide, firm base (which could be seen best, of course, in a view of the skull from underneath instead of from the side) which receives not only the backward thrusts transmitted through the rostrum, but also the forward thrusts upon the condyles coming from the backbone. The upper part of the skull is braced by a massive transverse crest formed by the supra-occipital, parietals, nasals, maxillæ, and premaxillæ; these bones are piled up into a sort of wide dome through which passes the vertically placed tube leading to the nostril at the summit. The premaxillæ and maxillæ thus not only form the upper part of the rostrum but are prolonged backward and upward on to this dome in order to support the massive "case" or spermaceti organ, which is a specialized part of the nose

paper with a section on the auditory apparatus, containing the following interesting paragraphs:

"The auditory apparatus of *Kogia*, as in other Cetacea, has thus been modified from an apparatus designed to receive air-borne sounds to one designed to receive water-borne sounds. The external meatus has been practically closed, the drum membrane fixed, and the ossicles rendered immovable by the fusion of the malleus to the os tympanum. Denker has thoroughly demonstrated that vibration of the ossicular chain is impossible. The water-borne sounds are evidently transmitted to the cochlear apparatus through the solid tissues of the head. This method of hearing is all the more efficient on account of the closing off of sounds borne through air, in accordance with the well-known clinical fact that bone conduction is increased where the function of the middle ear is diminished.

"The manner in which the sounds are transmitted to the cochlea is disputed. Some authorities maintain that the vibrations are transmitted to the air in the tympanum, and thence to the cochlea through the fenestra ovalis. Others say that the sound waves reach the receptive organs in the cochlea directly through the walls of the periotic bone. In this connection, it is important to recall that the os tympanum and the periotic are nowhere in contact with the other bones of the skull and that they are surrounded by numerous cells capable of distension with air. So it seems necessary to suppose that sound waves must reach the internal ear through a cushion of air immediately related to the periotic, though not necessarily that contained in the tympanum alone.

"The large relative size of the cochlear division of the periotic argues an active hearing function. On the other hand, the comparatively small size of the semicircular canals is what we should expect in an animal living in the water where little active balancing would be called for."

Architectural Features of the Whale Skull

Dr. Kernan has made a most thorough and detailed study[1] of two skulls of the

[1] Kernan, J. D., Jr., 1918. The Skull of *Ziphius cavirostris*. *Bull. Amer. Mus. Nat. Hist.*, XXXVIII, Art. 11, pp. 349–94, Pls. XX to XXXII. [Review furnished by Dr. W. K. Gregory.]

curiously specialized whale, *Ziphius cavirostris*, the one being that of a young adult female, the other that of a fœtus. The most interesting part of this paper for the general reader is the discussion of the architectural features of the skull, which enable it to resist various physical forces acting upon it in life.

"Three classes of forces may be thought of as acting upon the skull of cetaceans: water pressure; the vertical and lateral twists and strains upon the prolonged rostrum; and those incident to propulsion, due to the resistance of the water in front and the thrust of the vertebral column upon the condyles behind." (See page opposite.)

The New York Aquarium Guide Book

THE New York Aquarium has recently published under the authorship of Dr. C. H. Townsend, the director, a new *Guide*, attractively illustrated with photographs of many of the animals on exhibition. An introduction gives a brief history of the Aquarium, which is the largest in the world, and some interesting notes on the problems of maintaining and transporting fishes from tropical or northern, fresh or marine habitats. Strangely enough, showy tropical species are more easily cared for than local fresh or marine species. The importance of the temperature factor limits the life of many species in the Aquarium. Fishes from cold waters can exist only in winter in the Aquarium, as it is impossible in summer to keep the temperature of the water low enough. The converse is equally true. Limitations of space prevent the housing of more than about two hundred species in the building at any time.

The *Guide* gives brief accounts of about 150 of the most common aquarium fishes, both marine and fresh water, with such factors as range, economic importance, value for sport, and interesting habits. As the species are all arranged by families in the accepted scientific order, an excellent idea of their relationships can be obtained. The remainder of the book deals with turtles, alligators, frogs, salamanders, marine mammals, and invertebrates, on the same plan, although owing to the difficulty of providing proper habitats in the Aquarium, the number of species exhibited is necessarily much smaller. The Mosquito Hatching Exhibit in connection with the invertebrates has proved particularly attractive to visitors. A chapter on "Balanced Aquaria," and another on the "Care of Small Aquatic Animals," the latter contributed by Ida M. Mellen, present brief summaries of experience of value to all amateurs.—LUDLOW GRISCOM.

Notes

A COMMITTEE has been appointed by the friends and relatives of the late Dr. Henry Marcus Leipziger to found a memorial for him. The plan is to conduct annual lectures upon important subjects, and $10,000 of the desired $50,000 has already been pledged for the purpose.

DR. C. GORDON HEWITT, consulting zoölogist of the Canadian Conservation Commission, died at Ottawa on February 29, in his thirty-fifth year. Dr. Hewitt was one of the foremost champions of wild life conservation in North America. He will be remembered in that connection by readers of NATURAL HISTORY for his account of the "Coming Back of the Bison" in the December, 1919, number. He had been engaged for the last four years in the preparation of a book on the conservation of wild life in Canada which was completed shortly before his death and which will appear posthumously. Dr. Hewitt's services in connection with the ratification of the treaty between the United States and Canada for the protection of migratory birds were invaluable and brought recognition in 1918 from the British Royal Society for the Protection of Birds with the award of their gold medal.

THE American Museum through its department of ichthyology has received from

Dr. David Starr Jordan a gift of three slabs of diatomaceous earth containing fossilized fishes.

Dr. Herbert J. Spinden, of the American Museum, has been elected a corresponding member of the Society of Americanists of Paris.

The Lalande prize in astronomy of the Academy of Sciences of Paris has been awarded to Dr. V. M. Slipher, director of the Lowell Observatory, Flagstaff, Arizona.

Dr. Hugh P. Baker, dean of the New York State College of Forestry, has resigned from that institution to become secretary of the American Paper and Pulp Association. In his letter of resignation Dr. Baker stated that he accepted his new position as an opportunity to carry the profession of forestry into a great industry.

Dr. Jacques Loeb, head of the department of experimental biology at the Rockefeller Institute, was elected president of the American Society of Naturalists at their annual meeting in Princeton.

Mr. Felix M. Warburg, chairman of the Joint Distribution Committee of Funds for Jewish War Sufferers, and a trustee of the American Museum, has been notified by the Polish Minister of the award to him of a medal in recognition of his services in the relief of Poland.

Owing to the delayed date of printing this issue of Natural History we are able to include the following item:

The late Rear Admiral Robert E. Peary was awarded the first medal to be given by Kane Lodge, 454 F. & A. M., at the centenary celebration of Elisha Kent Kane's birth, which was attended by many distinguished explorers on March 30. The gold medal, which bears the seal of the Lodge and portrays an Arctic scene, was accepted by Peary's sixteen-year-old son. It is the first of a series to be presented "to those who by predominant achievement have added to the knowledge of mankind in those parts of the earth's surface previously unexplored or undeveloped."

The Agassiz Medal of the National Academy of Sciences, Washington, for research in oceanography, was awarded in 1919 to S. A. S. Albert I, Prince of Monaco.

President Henry Fairfield Osborn, of the American Museum, and Mrs. Osborn were recent visitors at Hilo, island of Hawaii, whence President Osborn journeyed to the active volcano, Kilauea, in company with Dr. Thomas A. Jaggar, director of the Hawaiian Volcano Observatory, and to the great forest reserve near Pahoa. From Hilo Professor and Mrs. Osborn will go to the island of Maui and perhaps also to Kauai and Niihau where primitive Hawaiian communities still maintain something of their ancient ways.

Mr. Roy Chapman Andrews, of the American Museum, has returned after an absence of nearly two years. Mr. Andrews was in charge of the Second Asiatic Zoölogical Expedition which the Museum sent out in 1918 to carry on zoölogical work in North China and Mongolia. A large collection of mammals was obtained, among which are mountain sheep holding the world's record for size, elk, moose, antelope, goral, wild boar, tiger, and serow, as well as more than a thousand small mammals.

Professor T. D. A. Cockerell in a recent number of *Science* tells of Darwin's method of investigation. He was a most faithful and persistent worker, and in addition he constantly sought the coöperation of friends and correspondents among his contemporaries. *The Origin of Species* reveals by its acknowledgments the great number who helped him. He directed and unified the experiments of others, acting as leader of an interrelated group, and thus his work has both the breadth and the accurateness that one man alone could not attain. In this respect Darwin worked under conditions different from those which confront present-day biological scientists, whose work is delegated to but one department of an institution, and the question may well be asked if we are not overdoing individualism.

Several of the microscopical trouble makers possible to our water supply, mentioned by Dr. Kahn in this number of Natural History, are to be seen among the glass models in the Darwin hall at the American Museum. These include *Synura uvela* (page 83) and *Volvox globator* (p. 85, No. 3 at the

right) which impart respectively the cucumber and fishy odors found in reservoir waters, and also *Gonium petrocale* (p. 85, No. 6 at the right) and the pond-frequenting *Stylobryon petiolatum*. The glass models of animalcules, enlarged many hundred diameters, were blown by Mr. H. O. Mueller, of the Museum's preparation staff, to illustrate the varieties of one-celled animals found abundantly wherever there is water, from the ocean bottom to the moist tissues of plants and animals. Of these the radiolarians which form a siliceous or "glassy" skeletal structure of marvelous symmetry and complexity are particularly fine objects for displaying the technique of the glass blower who must fashion the multitude of minute spicules from plain glass rods and tubes. The models have been made by reference to the actual animals under the microscope. Natural colors have been imparted either by colored glass or by oil paint applied with the air brush. In this exhibit one may conveniently study the structure of those very minute animals which, for the most part, are too small to be visible to the eye, yet which play such an important rôle in human health and comfort.

The Birds of Eastern Canada, by Dr. P. A. Taverner, has appeared as Memoir 104 of the Geological Survey of Canada. The major portion of the book is occupied with systematic accounts and some natural history notes of the various species, illustrated with one hundred reproductions in color. In addition, the work contains a bibliography of ornithological literature, and a number of introductory chapters on geographical distribution, migration, and protection, and on various means of attracting birds about the house.

A NEW monthly magazine, *Discovery*, has appeared this year in England under the editorship of Dr. A. S. Russell, professor of chemistry in the University of Sheffield. *Discovery* aims to record in popular form the "advance made in the chief subjects in which investigations are being actively pursued," both in the sciences and the humanities, by authors who speak with authority in their respective fields.

"SAVE the Redwoods Day," February 27, was the occasion of a conference of the Save the Redwoods League, held in San Francisco in connection with the Pacific Automobile Show, at the Municipal Auditorium.

DR. G. CLYDE FISHER, associate curator of the department of public education, and Dr. F. E. Lutz, associate curator of invertebrate zoölogy, will represent the American Museum at the annual conference of the American Camp Directors' Association to be held in May at Greenkill Camp near Kingston, New York. Dr. Lutz will have charge of the insect work, and Dr. Fisher of birds. The work is done in conjunction with the Woodcraft League of America, whose president, Ernest Thompson Seton, will have charge of the camp woodcraft.

THE fascination of fishing, and of learning unknown facts, the charm of the sea, and of free life in the open are blended to an unusual degree in a recent book by Zane Grey, *Tales of Fishes*. The volume deals mostly with the pursuit by rod and line of the largest and gamest salt-water fishes, the tarpon, swordfish and tuna.

AN expedition to Jamaica, undertaken jointly by the department of mammalogy and the department of vertebrate palæontology of the American Museum, under the leadership of Mr. H. E. Anthony, associate curator of mammals, has returned with a great mass of material. The collections, which date back to the Pleistocene era, comprise many hundreds of pounds of bone-bearing breccia found in the caves of Jamaica.

THE death is announced from Argentine of Dr. Francisco P. Moreno, anthropologist, naturalist, explorer, and pioneer in the promotion of scientific institutions and research in that country. Dr. Moreno founded the Anthropological and Archæological Museum of Buenos Aires in 1877 and the La Plata Museum in 1889, and was director of the latter until 1907. He was well known in Europe, especially in connection with his voluminous labors on the Argentine-Chile boundary dispute on which he spent many years.

THE second annual meeting of the American Society of Mammalogists will be held in New York City, May 3–5, at the American Museum of Natural History.

THE Brooklyn Museum Peruvian Littoral Expedition, which sailed last August for Peru under the leadership of Mr. Robert Cushman Murphy, curator of the department of natural science, has returned to New York. The expedition completed a comprehensive survey of the avifauna of the Peruvian Current and of the coastal islands. Many still and moving pictures were taken of the colonies of pelicans, cormorants, and other sea birds which nest on the islands.

THE Carnegie Corporation of New York has given $5,000,000 to the National Academy of Sciences and the National Research Council for the construction of a suitable building and the endowment of the Council.

DR. BURTON E. LIVINGSTON, professor of plant physiology in Johns Hopkins University, has been elected permanent secretary of the American Association for the Advancement of Science to succeed Dr. L. O. Howard, now president of the Association.

THE first number of the *Bulletin of the National Research Council* appeared in October and was devoted to a general discussion of the national importance of scientific and industrial research by Professor George Ellery Hale, honorary chairman, the Honorable Elihu Root, Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching, and several notable representatives of large industries, members of the advisory committee of the Council. The *Bulletin* is to be devoted to illustrations of the possibilities of coöperative research and of the methods and successes in various branches of science and technology.

THE progress of the British Museum (Natural History) since its removal to special buildings in South Kensington in 1882–83 is recorded in a letter to *Nature* by the director, Dr. S. F. Harmer. At the time of this change it is estimated that the number of specimens in the department of zoölogy was about 1,400,000. These have increased to 6,000,000 and there has been a proportionate increase in other departments. The Museum has also accomplished much in the way of exhibiting its collections for educational purposes in accordance with a change of view as to the public functions of museums in general. The evolution of animals, geological history, habitat groups, and many other exhibits of a general nature have been arranged for the public during the last quarter century.

DR. J. PERCY MOORE, of the Federal Bureau of Fisheries, investigated last summer in the Palisades Interstate Park an important method of eliminating mosquitoes. Dr. Moore, while a member of a party representing the Bureau and the New York State College of Forestry which was studying the fish conditions of the park, demonstrated that pools and inlets, the entrances to which were obstructed to fish by the growth and accumulation of plants, harbor great numbers of mosquito larvæ. When the plants were cleared away and the shore line opened, the fish destroyed the greater number of the larvæ, as was proved by subsequent examination of the water and of the stomach contents of the fish.

AT the request of Dr. Gustave Straubenmüller, associate superintendent of the public schools of New York City, the American Museum, through its department of education, has inaugurated a series of lectures for student-teachers. The New York Training School for Teachers at One Hundred and Twentieth Street has been made the lecture center upon the suggestion of the principal, Mr. Hugo Newman.

THE lecture by Mr. William L. Finley on February 21, at the American Museum, was made doubly interesting by excellent pictures. Views of the ptarmigan, water ouzel, grebe, and chipmunk were particularly fine, and gave evidence of an unusual ability in the handling of wild life. The water ouzel was shown playing about the rocks and plunging into icy brooks. The grebe, also a brilliant performer under water, covered its eggs carefully with rushes to preserve them from crows, before going off to feed. A ptarmigan, a bird almost extinct in the United States, allowed Mr. Finley to stroke its back and raise it high enough from its nest to show the eggs. The chipmunk was an acrobat; he gave a "tight-rope performance" on a tent guy, and hauled up and opened paper parcels containing nuts which had been tied to it.